ENGINEERING

An Illustrated Weekly Journal

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Vol. 181 No. 4706 *LONDON, FRIDAY, MAY* 18, 1956 PRICE 2s.

NG A ROLLING-MILL CHOCK

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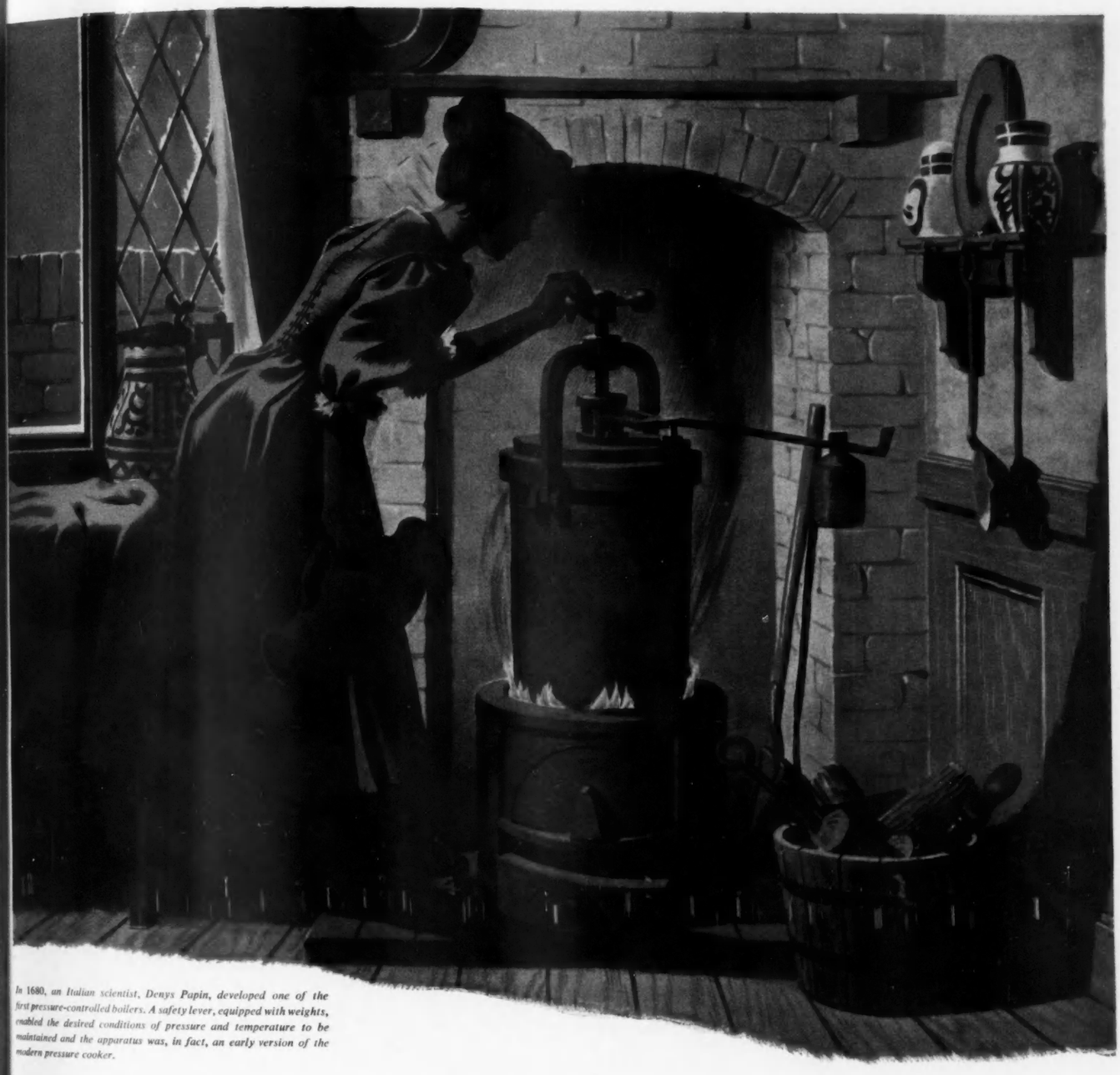

In 1680, an Italian scientist, Denys Papin, developed one of the first pressure-controlled boilers. A safety lever, equipped with weights, enabled the desired conditions of pressure and temperature to be maintained and the apparatus was, in fact, an early version of the modern pressure cooker.

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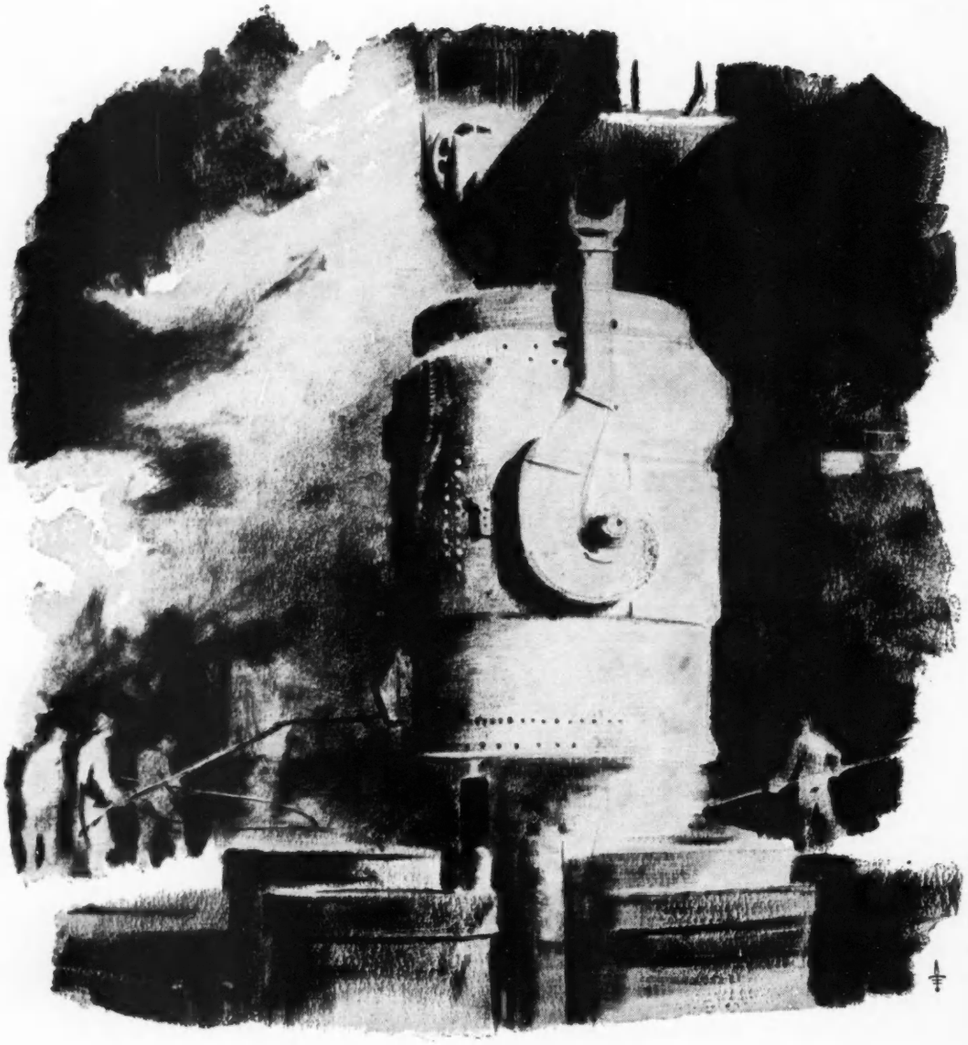

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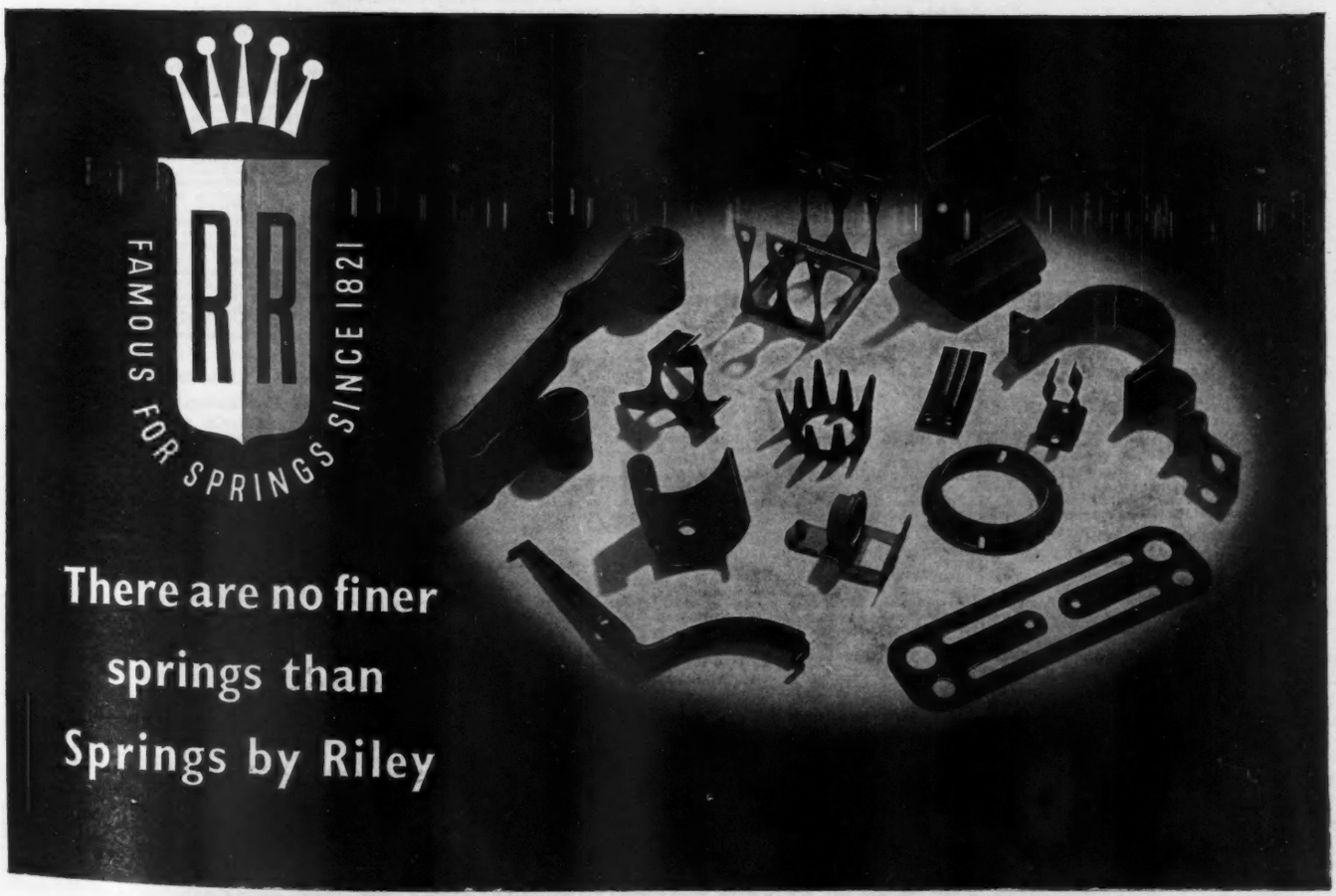

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PUBLIC NOTICE.

UNIVERSITY OF GLASGOW.

LONDON LECTURESHIP IN ENGINEERING PRODUCTION.

Applications are invited for the post of **PART-TIME LECTURER** in Engineering Production in the Faculty of Engineering. Candidates should be resident in the Glasgow neighbourhood, and occupy positions of responsibility in engineering works. The salary, which is expected to be about £1000 per annum, will be according to experience and qualifications. Full particulars of the duties may be obtained from the undersigned, to whom applications (5 copies) should be sent not later than 16th June, 1956.

ROBT. T. HUCHESON,
Secretary of University Court.
L 648

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SHELL STUDENTSHIPS IN CHEMICAL ENGINEERING from October, 1956. Each is of the value of £375 with free tuition in Chemical Engineering. The holders may work for the College Diploma in Chemical Engineering, or for a higher degree in that Department. Application forms from the REGISTRAR, KING'S COLLEGE, STRAND, W.C.2, whom completed applications must reach by 9th June. L 637

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Three Year Course for students who have attained a suitable standard.

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	SPECIFICATION.	QUANTITY NOS.
LIGHT ALLOY RIVETS: Snap head, CSK rivet and mushroom head rivet	B.S. 641	982,663

Forms of tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, on or after 18th May, 1956, at a fee of 10s. which is not returnable. If payment is made by cheque, it should please be made payable to "HIGH COMMISSIONER FOR INDIA." Tenders are to be delivered by 2 p.m., Friday 22nd June, 1956.
Please quote reference No. 426/55/RLY. L 575

THE HIGH COMMISSIONER FOR INDIA invites

TENDERS for the supply of:—

	I.R.S. SPECN. NO.	QUANTITY NOS.
FISH BOLTS WITH NUTS and SPRING WASHERS of various sizes	T-3-54	62,060

Forms of tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, on or after 18th May, 1956, at a fee of 10s. which is not returnable. If payment is made by cheque, it should please be made payable to "HIGH COMMISSIONER FOR INDIA." Tenders are to be delivered by 2 p.m. Friday, 22nd June, 1956.
Please quote reference No. 377/55/RLY. L 576

THE HIGH COMMISSIONER FOR INDIA invites

TENDERS for the supply of:—

	SPECIFICATION.	QUANTITY NOS.
SCREW, BOLTS AND NUTS of various sizes	B.S. 450 B.S. 57 B.S. 1083	796640

Forms of Tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, on or after 18th May, 1956, at a fee of 10s. which is not returnable. If payment is made by cheque, it should please be made payable to "HIGH COMMISSIONER FOR INDIA." Tenders are to be delivered by 2 p.m., Friday, 22nd June, 1956.
Please quote reference No. 454/55/RLY. L 574

BUCKINGHAMSHIRE EDUCATION COMMITTEE.

TENDERS are invited for the following items of engineering equipment which are required for the new College of Further Education, Slough:—

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MYFORD CYLINDRICAL GRINDER, 5 IN. BY 12 IN.
JONES & SHIPMAN MODEL 1204/EIUR 8 IN. BY 22 IN. CYLINDRICAL GRINDER.
JONES & SHIPMAN MODEL 540 18 IN. BY 6 IN. SURFACE GRINDER.
"EXCELL" NO. 1 PRECISION PEDESTAL SURFACE GRINDING MACHINE.
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"VICTORIA" MODEL O.2 OMNIMIL VERTICAL MILLING MACHINE.
"PROGRESS" MODEL 1.S PILLAR DRILLING MACHINE.
"CORONA" MODEL 21.A.N. BOX COLUMN DRILLING MACHINE.
"WICKSTEED" HYDRAULIC RESISTANCE METAL POWER SAWING MACHINE.
"HOLBROOK" MODEL C.10 HIGH SPEED PRECISION RELIEVING LATHE.
B.S.A. VERTICAL BROACHING MACHINE, 7½ tons capacity.
"TAYLOR-HOBSON" TYPE C.X. ENGRAVING MACHINE.

Firms interested should make application for tender forms to the undersigned within ten days of the date of the appearance of this advertisement

D. E. COOKE,
Chief Education Officer.

County Offices,
AYLESBURY. L 655

THE HIGH COMMISSIONER FOR INDIA invites

TENDERS for the supply of:—

	QUANTITY NOS.
RIVETS, LIGHT ALLOY ...	1,246,260

Forms of tender may be obtained from the DIRECTOR GENERAL, INDIA STORE DEPARTMENT, GOVERNMENT BUILDING, BROMYARD AVENUE, ACTON, LONDON, W.3, at a fee of 10s. which is not returnable. If payment is made by cheque, it should please be made payable to "HIGH COMMISSIONER FOR INDIA." Tenders are to be delivered by 2 p.m., Friday, 29th June, 1956.
Please quote reference No. 25/56/RLY. L 652

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ROYAL NAVAL SCIENTIFIC SERVICE.

DRAUGHTSMEN required in Admiralty Research and Development Establishments in London (Teddington area), Portsmouth, Weymouth, and Baldock (Herts) for the design of experimental apparatus needed for fundamental research or for fitting in H.M. ships. Experience is necessary in any of the following classes of equipment: light to medium electrical, electro-mechanical, precision mechanical and electronic.

Candidates must be British aged 21 years or over, with at least 3 years' practical workshop training and, preferably, with drawing office experience and/or possession of the O.N.C. or equivalent.

Appointments unestablished, but opportunities will occur to compete for established posts and for promotion.

Starting pay (London rate), £463 10s. per annum (aged 21), £635 (aged 28) rising by 4 increments to £725 per annum; slightly less in the Provinces.

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Applicants for the Senior Lecturer and Grade I posts should have industrial or research experience and be willing to teach at University degree stages.

All applicants should have an honours degree or equivalent qualification. Successful applicants will be given a placing on the scales appropriate to approved experience. Further particulars may be obtained from the undersigned.

H. N. HENRY,
Principal. L 647

COUNTY BOROUGH OF GRIMSBY.

EDUCATION COMMITTEE.

COLLEGE OF FURTHER EDUCATION.

PRINCIPAL: E. S. GREEN, B.Sc., A.R.I.C.

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Applications are invited for the following posts:—

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(B) ASSISTANT (GRADE B) to teach Engineering subjects up to A.I. level. These include Mathematics, Science and Engineering Drawing.

Applicants for both posts must possess recognised technical qualifications and industrial experience. Salary Burnham Technical Scale. Increments in respect of approved teaching and industrial experience. Duties to commence on 1st September, 1956.

Application forms (stamped addressed envelope) from the undersigned, to be returned by 2nd June, 1956. Canvassing disqualifies.

R. E. RICHARDSON,
DIRECTOR OF EDUCATION.

EDUCATION OFFICE,
ELEANOR STREET,
GRIMSBY. L 670

THE COLLEGE OF AERONAUTICS.

Vacancies exist for

ENGINEERS/DEMONSTRATORS in the DEPARTMENT OF AIRCRAFT PROPULSION to work on all forms of aircraft and guided weapon power plants or their components. These include rockets, ramjets, gas turbines, piston engines and associated subjects such as combustion, heat transfer, and mechanical testing. Much of the work involves operation of full scale engines. Those appointed will be responsible, under the direction of lecturers, for preparation and supervision of students' experimental work in the field in which they are experienced. They will assist in research work and opportunities for extending experience will be provided. Salary, according to qualifications and experience, on a scale rising to £900 p.a. with superannuation under F.S.S.U., and family allowances. House may be available. Applications giving full particulars of qualifications and experience and containing the names of three referees, to THE RECORDER, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS., from whom further details may be obtained. L 583

LONDON COUNTY COUNCIL.

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ENGINEERING ASSISTANTS (up to £818) and **ENGINEER GRADE III** (up to £987) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from ARCHITECT (AR/EK/SE/1) THE COUNTY HALL, S.E.1. (1278). G 573

THE UNIVERSITY OF SHEFFIELD.

Applications are invited for a post of **LECTURER IN MECHANICAL ENGINEERING,** to begin duties on 1st July, 1956, or as soon as possible thereafter. Salary scale, £650 by £50 to £1350, with F.S.S.U. provision and family allowances. Initial salary according to qualifications and experience.—Further particulars should be obtained from the REGISTRAR, to whom applications (4 copies) should be sent by 9th June, 1956. L 650

SARAWAK.

ROAD ENGINEER.

PUBLIC WORKS DEPARTMENT.

Appointment on contract/gratuity terms. Salary £2093 per annum. Free Passages: Free Medical Attention. Generous Home Leave. NO INCOME TAX. Substantial Gratuity. Candidates must be Corporate Members of Institution of Civil Engineers or hold recognised engineering degree or equivalent qualification, and have had wide practical experience on road location, design and construction.

APPLY—DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1. Give details of age, qualifications, experience. Quote BCD. 112/24/05/D5. L 624

TECHNICIANS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE.

POST "A" (Ref. A501/26).—To assist in the control of a section responsible for:—
(a) the provision, installation, modification and maintenance of machine tools, equipment and fixtures.
(b) the investigation of machining techniques in collaboration with scientists and design engineers;
(c) development of special fixtures and modifications to machine tools;
(d) liaison with contracts branches and machine tools manufacturers.
Applicants should have served a recognized engineering apprenticeship. A good knowledge of machine tools in general use and current workshops practice is essential. Previous experience of duties of the type detailed above and possession of H.N.C. or equivalent qualification an advantage.

POST "B" (Ref. 860/26).—To control technical and industrial staff in the efficient operation of precision experimental workshops working for and in close liaison with scientific staff on the manufacture of experimental prototype equipment for an explosive group. Applicants should have served a recognised engineering apprenticeship and preferably possess a H.N.C. or equivalent qualification. They should be experienced in machine shop practice. A knowledge of electrical engineering and of the regulations governing the handling of explosives would be an advantage.

SALARY: £873 to £1080 per annum.

Contributory Superannuation Scheme. Successful married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates; alternatively assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to SENIOR RECRUITMENT OFFICER at the above address, not later than May 22nd, quoting the appropriate reference number. L 588

THE UNIVERSITY OF LEEDS.

DEPARTMENT OF MECHANICAL ENGINEERING.

Applications are invited for appointment as **LECTURER IN THE DEPARTMENT OF MECHANICAL ENGINEERING** at a salary on the scale £650 by £50 to £1350 a year, according to qualifications and experience. The person appointed would be expected to teach in the field of control engineering including the application of automatic control to production engineering. This is a new post and the holder will be responsible for developing the subject within the department. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the REGISTRAR, THE UNIVERSITY, LEEDS, 2 (from whom further particulars may be obtained) not later than 11th June, 1956. L 612

THE UNIVERSITY OF SHEFFIELD.

Applications are invited for a post of **LECTURER IN CIVIL ENGINEERING** to begin duties on 1st October, 1956, or as soon thereafter as possible. Salary scale £650 by £50 to £1350, with F.S.S.U. provision and family allowance. Commencing salary according to qualifications and experience. Further information should be obtained from the REGISTRAR, to whom applications (4 copies) should be sent by 18th June, 1956. L 618

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF SUPPPLY.

DEFENCE STANDARDS LABORATORIES, ALEXANDRIA, NEW SOUTH WALES.

Applications are invited for a temporary position of **SCIENTIFIC OFFICER, GRADE I** at the above Laboratories.

SALARY.—£1263 to £1578 per annum.

DUTIES.—Research and investigational work in Physical Metallurgy under direction of Head, Metallurgy Group.

QUALIFICATIONS.—Degree of high standard in Science or Engineering with Metallurgy as a major subject.

The salaries quoted are Australian currency.

Whilst the position is a temporary one, the tenure of employment is not limited.

Under specified conditions, first class boat fare (if first class berth is available), for the appointee and dependants (wife and dependent children) will be paid by the Commonwealth.

Application forms obtainable from:—
SENIOR REPRESENTATIVE (AP.57),
DEPARTMENT OF SUPPLY,
AUSTRALIA HOUSE,
STRAND, LONDON, W.C.2.
with whom applications should be lodged by 7th June, 1956. L 656

UNIVERSITY COLLEGE OF SWANSEA.

Applications are invited for EITHER an **ASSISTANT LECTURESHIP** or **A LECTURESHIP IN MECHANICAL ENGINEERING.**

Salaries:—
Assistant Lectureship, not less than £550 per annum.
Lectureship £650 by £50 to £1350 per annum.

Commencing salary in each case will be at a point on the appropriate scale according to age, qualifications and experience. The initial salary for the Lectureship will not be higher than £1,000. Membership of the F.S.S.U. and children's allowance scheme.

Further particulars may be obtained from the REGISTRAR, UNIVERSITY COLLEGE, SINGLETON PARK, SWANSEA, to whom applications (six copies) must be sent by JUNE 5, 1956. L 600

FIJI—PUBLIC WORKS DEPARTMENT.

ROAD LOCATION ENGINEER.

Appointment on contract/gratuity terms. Salary in incremental scale £1486 to £1621. Free Passages; Free medical attention for Officers. Generous leave. Low Income Tax.

Candidates should be Chartered Civil Engineers or hold a University degree or diploma which carries exemption from Final Parts I and II of the A.M.I.C.E. examination and have not less than 5 years experience on location of new country roads and preparation of plans for a road design office.

Apply—DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1. Give details of age, qualifications and experience. Quote BCD. 112/49/016/D5. L 625

NYASALAND.

EXECUTIVE ENGINEERS.

Appointment on probation for permanent and pensionable establishment with Salary in scale £980 to £1850 according to qualifications and experience or on contract/gratuity terms with salary £1410 to £1850 plus gratuity of £150 per annum. Free passages. Free Medical attention: Generous home leave. Low Income Tax.

Candidates should hold a University degree or diploma recognised as exempting from or have passed Final Parts I and II of the A.M.I.C.E. examination. Not less than two years practical civil engineering experience preferably on roads.

Apply—DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1. Give details of age, qualifications experience. Quote BCD 112/4/02/D5. L 628

ROCHDALE EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

Applications are invited for the undermentioned posts:

ENGINEERING DEPARTMENT:

ASSISTANT (GRADE B) TO TEACH MECHANICAL ENGINEERING subjects to O.N.C. and H.N.C. levels.

ASSISTANT (GRADE A) TO TEACH MECHANICAL ENGINEERING and Workshop subjects to O.N.C. level and Machine Shop Engineering to Final City and Guilds level.

ASSISTANT (GRADE A) TO TEACH WELDING and/or Sheet Metal Work to Final City and Guilds level.

ASSISTANT (GRADE A) to teach Electrical Installation and General Electrical subjects to Final City and Guilds Examinations.

Applications to be returned by 25th May, obtainable from CHIEF EDUCATION OFFICER, EDUCATION OFFICE, FLEECE STREET, ROCHDALE. L 633

ST. LAWRENCE'S (MENTAL DEFICIENCY) HOSPITAL, CATERHAM SURREY.
(2,280 beds).

ASSISTANT ENGINEER required. Salary £585 by £20 (1) by £25 (4) to £705 per annum. P.T.B. conditions. House available at moderate rent. Candidates should possess Ordinary National Certificate in Mechanical Engineering or approved equivalent qualification, and have had appropriate practical experience (Mechanical and electrical).

Applications, stating age, qualifications and experience, with names of two referees to reach GROUP SECRETARY, by 28th May, 1956. L 585

ATOMIC ENERGY RESEARCH ESTABLISHMENT,

HARWELL

has vacancies for

ASSISTANT EXPERIMENTAL OFFICERS

in its Engineering Services Division.

(i) To carry out the more precise analytical work needed for the chemical service to new water moderated reactors, and to supervise less qualified staff.

(ii) To operate a chemical service for novel experiments connected with the development of new reactors.

G.E.C. Advanced level in two science subjects, or equivalent qualifications essential. Experience of industrial water treatment techniques an advantage. For (i) experience in the estimation of trace elements is desirable.

SALARY: £330 (at age 18) to £718 per annum (male).

Contributory pension scheme; five day week; excellent working conditions and generous leave allowances.

Note.—Married officers living outside the Establishment's transport area will be eligible for housing under Authority arrangements or, alternatively, substantial assistance towards legal expenses incurred in house purchase, will be available.

Send POSTCARD for application form which must be returned by 29th May, 1956, to ESTABLISHMENT OFFICER, A.E.R.E., HARWELL, DIDCOT, BERKS, quoting reference 552/26. L 587

AIR MINISTRY
require

CIVIL ENGINEERS in Works Directorate for supervision of constructional and maintenance work home and abroad. Salary in basic grade £800 p.a. at age 25 rising annually to £1252. Lodging allowance payable under certain conditions. Main grade £1252 p.a. rising annually to £1620 p.a., somewhat lower in provinces. Appointments temporary with long term possibilities. Overseas allowance up to £1500 p.a. Candidates normally must be natural born British subjects. Quals.: basic grade, B.Sc.(Eng.), or equivalent or Parts I and II of Institution of Civil Engineers, Testamur, of Institution of Municipal Engineers, must also have had two years good civil engineering experience; for main grade A.M.I.C.E. or A.M.I.Mun.E. Application form quoting reference E.41/6A for basic grade and E.40/6A for main grade from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), ALMACK HOUSE, 26 KING STREET, LONDON, S.W.1. L 645

D.S.I.R. require an

ASSISTANT EXPERIMENTAL OFFICER at Ditton Laboratory, near Maidstone, Kent, for work on Engineering and physical problems of refrigeration applied to food preservation. Qualifications, G.C.E. advanced level in Maths. and Physics, with interest in mathematical treatment of data. Over 22, pass degree or H.N.C. in Mechanical Engineering generally expected. Salary (under review), Men £328 (age 17) to £706; Women £328 to £634, subject to improvement under Equal Pay Scheme. Forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C.359/6A. Closing date 9th June, 1956. L 643

POST OFFICE.

ASSISTANT ENGINEER. The Civil Service Commissioners announce an open competition commencing 14th August, 1956, for not less than 50 posts for men. Age at least 17½ and under 23½ on 1st March, 1956, with extension for service in H.M. Forces and, up to two years, for established civil service.

Starting salary (London) according to age from £445 (at 18) up to £615 at age 25 or over on entry. Maximum £900. Somewhat lower in provinces.

For particulars (including prospects) and application form write (preferably by postcard) to SECRETARY, CIVIL SERVICE COMMISSION, BURLINGTON GARDENS, LONDON, W.1, quoting No. 159/56/84. Application forms must be returned by 21st June, 1956. L 644

THE SUPERVISOR'S GUIDES. No. 4 Factory Organization By J. Munro Fraser, M.A., and B. W. Gould, M.I.Prod.E., A.M.I.E.E. This book is the latest addition to a very popular series. It forms a concise guide to factory management produced specially in suitable form for supervisors and foremen. 3s. net.

MANAGEMENT SURVEY
By F. C. Hooper B.SC., F.I.I.A. This book's great achievement is to show clearly the vital importance of good management in the structure of our modern society. Written especially for the layman and beginner in business, it will also be welcomed by the experienced manager. 18s. net.

ENGINEERING DESIGN
By J. E. Taylor, M.SC.TECH. and J. S. Wrigley, M.SC. Third Edition. A textbook for students of engineering preparing for the Ordinary and Higher National Certificates and for University Degrees in the subject. Pitman's Engineering Degree Series. 25s. net.

"Here is a type of book which should find a place on the shelves of every engineering student."—PRACTICAL ENGINEERING.

BOILER PLANT TECHNOLOGY
By R. L. Batley, O.B.E., A.M.I.MECH.E. and E. Gordon Barber, B.SC.HONS. (LOND.), A.R.I.C., F.R.P.S. Third Edition. This book embodies the results of research made co-operatively by an engineer and a chemist and thus approaches the subject from a scientific as well as from an engineering angle. This new edition has been revised and extended to cover fully the modern developments in the subject. Illustrated. 28s. net.

PITMAN **technical books**
Parker Street, Kingsway, London, W.C.2

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE,

requires

ENGINEERS (Basic Grade)

and

TECHNICIANS

for the following posts:—

ENGINEERS. Posts A ref. 823/26, to be responsible for engineering, through the design to the production stage, a wide variety of electronic and electronic-mechanical instruments to meet scientists' requirements and for the production of prototypes. Applicants should have served a recognised engineering apprenticeship and either be corporate members of the I.E.E. or possess exempting qualifications. A good knowledge of electronic instruments and circuit practice is essential. A knowledge of the use of plastics in component work would be an advantage.

TECHNICIAN. Post B, Ref. 1007/26, to take charge of a wiring and assembly shop engaged in the production of a wide range of electronic and electro-mechanical instruments. Applicants should have served a recognised engineering apprenticeship and have a wide practical experience of the methods of manufacture and inspection of electronic instruments including coil and transformer winding and impregnation. They should also be used to handling big voltage equipment and be able to control male and female labour. A knowledge of the manufacture of paper type condensers would be an advantage.

SALARY: Engineer (Basic Grade), £728 to £1130 p.a.
Technician, £743 (at age 30 or over) to £873 p.a.

Contribution Superannuation Scheme. Successful married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates; alternatively assistance towards legal expenses incurred in house purchase may be available. Until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to SENIOR RECRUITMENT OFFICER at the above address, quoting the appropriate reference number, not later than May 22nd, 1956. L 589

Classified Advertisements continued on Page 4

ATOMIC ENERGY RESEARCH ESTABLISHMENT,

HARWELL

has vacancies for

ENGINEERS

in the newly created

REACTOR DIVISION, which is responsible for the study and development of new types of nuclear reactors, engineering design of zero energy systems, research reactors and reactor experiments, and for Engineering and Reactor Physics research.

Appointments covering a wide variety of interesting and important work will be made in the following grades:

Principal Scientific Officer: £1270 to £1680 p.a.
Senior Scientific Officer: £1105 to £1270 p.a.
Scientific Officer: £528 to £948 p.a.

(1st or 2nd Class Honours degree in Engineering or Applied Mathematics, or equivalent essential. For senior posts some industrial experience desirable).

Engineer I: £1490 to £1685 p.a.
Engineer II: £1130 to £1435 p.a.
Engineer III: £728 (at age 25) to £1130 p.a.

(Applicants for these posts, must have served a recognized engineering apprenticeship, or have had equivalent training, and be corporate members of a senior professional institution, or hold exempting qualifications. A 1st or 2nd class Honours degree in Engineering would be an advantage. For the senior posts, considerable industrial experience is essential).

Senior Experimental Officer: £1155 to £1350 p.a.
Experimental Officer: £808 to £988 p.a.
Assistant Experimental Officer: £330 (at age 18) to £718 p.a.

(G.C.E. Advanced level or an equivalent, in Science subjects essential).

Contributory pension scheme.—five-day week; excellent working conditions and generous leave allowances.

Married officers living outside the Establishment's transport area will be eligible for housing under Authority arrangements or, alternatively, substantial assistance towards legal expenses incurred in house purchase will be available.

Send POSTCARD for application form, which must be returned by 28th May, 1956, to ESTABLISHMENT OFFICER, A.E.R.E., HARWELL, DIDCOT, BERKS, quoting reference 551/26. L 586

MIDDLESEX COUNTY COUNCIL.

COUNTY ATCHITECT'S DEPT.

STRUCTURAL ENGINEERS, APT. V (£795 to £970 p.a., plus weighting). Should be experienced in design and detailing of framed structures in reinforced concrete and structural steelwork and supervision of draughtsmen.

JUNIOR STRUCTURAL ENGINEERING ASSISTANTS, £595 to £675 plus weighting. To assist in detailing of framed structures in reinforced concrete and structural steelwork and preparation of steel schedules. Commencing salaries according to ability and experience. London Weighting additional £30 at 26 yrs. and over, £20 at 21 to 25 yrs. Five-day week of 38 hours. Established and pensionable. Prescribed conditions. Application forms (stamped addressed foolscap envelope) from COUNTY ARCHITECT, 1, QUEEN ANNE'S GATE BUILDINGS, DARTMOUTH STREET, S.W.1, returnable by 22nd June. (Quote S.840 E). Canvassing disqualifies. L 590

CLYDE NAVIGATION TRUST.

Applications are invited for the following appointments on the Engineering Staff of the Trust:—

JUNIOR ENGINEERING ASSISTANTS. Salary scale £400 to £850 per annum. Commencing salary according to age and experience. Applicants should have had a good technical training and drawing office experience and should possess a University Degree or have passed Part I of the Associate Membership Examination of the Institution of Civil Engineers, or hold equivalent qualifications. Experience in harbour work would be an advantage.

The successful applicants may be required to pass a medical examination and become members of the Trustees' Superannuation Fund.

Applications stating age, qualifications, etc., are to be lodged with the ENGINEER, CLYDE NAVIGATION TRUST, 16, ROBERTSON STREET, GLASGOW, C.2, not later than Monday, 11th June, 1956. L 578

NORTH STAFFORDSHIRE TECHNICAL COLLEGE, STOKE-ON-TRENT.

PRINCIPAL: H. W. WEBB, O.B.E., D.Sc.

Applications are invited for the full-time post of **LECTURER IN MECHANICAL ENGINEERING** to commence in September 1956. Applicants should preferably possess a degree or equivalent qualification and be capable of teaching to degree and Higher National Certificate standard one or more of the subjects Strength of Materials, Mechanics of Machines, Mechanics of Fluids, or Applied Thermodynamics. Salary according to the Burnham Technical Scale Lecturer, Grade, which is at present £965 to £1065. Salaries are now under review.

Applications giving details of age, qualifications, training and experience, together with the names of two referees, should be sent to the Principal immediately.

H. DIBDEN,
Clerk to the Governors. L 662

PORT OF MANCHESTER.

The Manchester Ship Canal Company have a vacancy for an

ASSISTANT MECHANICAL ENGINEER. Applications for the position, which will carry excellent prospects of promotion, are invited from candidates who should be about 40 years of age, preferably holding a university degree in mechanical engineering or other suitable qualification and with practical experience in a position of responsibility. The salary offered will be in accordance with qualifications.

Applications, containing particulars of age, education, professional qualifications and experience, should be addressed to the MECHANICAL ENGINEER, MANCHESTER SHIP CANAL COMPANY, SHIP CANAL HOUSE, KING STREET, MANCHESTER, 2, not later than 31st May, 1956; envelopes should be marked "A.M.E. Personal." L 640

CENTRAL ELECTRICITY AUTHORITY.

EASTERN DIVISION.

Applications are invited for the following appointments in the Generation (Construction) Department at Divisional Headquarters in North London:—

CIVIL AND STRUCTURAL DESIGNER DRAUGHTSMEN.

Salary N.J.B., Schedule "D," within the range of Grade 4/5, £735 by £20 to £955 per annum including London Weighting.

The commencing salary will depend on experience and qualifications.

The candidates appointed will be required to undertake civil and structural design work and applicants should have had experience in the design and detailing of reinforced concrete structures for heavy plant, culverts, etc., and structural steelwork as applied to industrial buildings.

Applications stating age, qualifications and experience should be sent to the CONTROLLER, CENTRAL ELECTRICITY AUTHORITY, EASTERN DIVISION, NORTHMET HOUSE, SOUTHGATE, N.14, by 26th May, 1956.

W. N. C. CLINCH,
CONTROLLER. L 661

DESIGN ENGINEERS.

are required
by the Industrial Group of the
UNITED KINGDOM ATOMIC ENERGY AUTHORITY
at its Headquarters,
RISLEY, NEAR WARRINGTON, Lancs.

Duties:

Successful applicants will be attached to one of the Design Groups responsible for the pioneering of large industrial projects which may be either nuclear power reactors or the associated chemical plants. The work is often novel in character and is wide in scope, but designers experienced in high quality plant engineering or machine design should experience little difficulty in adapting themselves.

Qualifications and experience.

Applicants should have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or hold equivalent qualifications. Possession of a University Degree in Engineering may be an advantage.

Salary.

Will be assessed within the range of £1199 *rising by annual increments of approximately* £40 *to* £1776 *p.a.*

The posts are permanent and new entrants under the age of 55 automatically join the Authority's Pension Scheme.

Generous Leave Allowance.

Suitably qualified persons are invited to send a postcard, quoting Ref. 1422 for application form to: THE RECRUITMENT OFFICER, U.K.A.E.A., INDUSTRIAL GROUP H.Q., RISLEY, WARRINGTON, LANCS.

Closing Date: 1st June, 1956.

L641

APPOINTMENTS OPEN.

EXPERIENCED PLANNING ENGINEERS required for production methods on medium I.C. engine components and fuel injection equipment. Pleasant working conditions, generous salary. Attractive Pension Scheme and Comprehensive Welfare Facilities.

Apply CHIEF PERSONNEL OFFICER, PETTERS LIMITED, CAUSEWAY WORKS, STAINES, MIDDX. G 662A

WILTON ICI WORKS

ENGINEERING DESIGNERS

The construction of the Company's factory at Wilton on a 2000-acre site has proceeded continuously since 1946 and now over ten million pounds are spent each year on new works. Staff with experience in design of modern works are required for this development.

The immediate vacancies are in the Design Office for :—

ASSISTANT TECHNICAL OFFICERS
MECHANICAL ELECTRICAL
CIVIL STRUCTURAL
INSTRUMENT

The appointments are to permanent staff and the Company is anxious to engage men who have had first rate experience to assist with the long-term plans for further development. Candidates in this category will be invited to interview, without commitment, at the Company's expense.

SALARIES
Commencing salaries up to £900 per annum will depend on the age and experience of candidates. The salaries of men engaged will be reviewed annually.

TERMS OF EMPLOYMENT
Five-day, 39-hour working week, Pension Fund, Profit Sharing Scheme, etc.

HOUSING
After joining the staff married men will receive a reasonable refund of removal (including travel) expenses, and to assist them in house purchase, facilities are available in approved cases for substantial loans; in addition, legal charges will be advanced.

Assistance is given in the procuring of rented houses, flats or lodgings.

Wilton is situated at the foot of the Cleveland Hills in Yorkshire, five miles from the coast. Working conditions are good and recreation facilities, including golf, tennis and badminton, are available.

Write for application form to: Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting advertisement reference ICI/X/302/e. L 541

MECHANICS (aged 27-40) with experience of electro-mechanical instrument making required as Test Bench Inspectors on specialised telecommunication apparatus. Good prospects for the right men who take a pride in their work. Pension Scheme. Staff restaurant.—PERSONNEL OFFICER, CABLE AND WIRELESS LIMITED, THEOBALDS ROAD, W.C.1. L 606

INSTALLATION ENGINEER. Manufacturers of diesel and electrical components for the motor industry require an experienced Installation Engineer, 25-40 yrs., for work in conjunction with the Design Dept. Education to H.N.C. preferred, although experience in similar work would be considered in the absence of academic qualifications. Apply in writing giving full details including salary required to—PERSONNEL OFFICER, SIMMS MOTOR UNITS, LTD., OAK LANE, E. FINCHLEY, N.2. L 597

ELECTRICAL ENGINEERS FOR PROJECT DEVELOPMENT.

Project Engineers for Electrical Plant are required by Group with Headquarters in Birmingham. Candidates should have extensive experience in industrial plant and Corporate Membership of The Institution of Electrical Engineering is a desirable qualification. Pension Scheme. Applications giving education, age, details of experience and present salary level should be addressed to PERSONNEL MANAGER, TUBE INVESTMENTS (GROUP SERVICES), LIMITED, ROCKY LANE, ASTON, BIRMINGHAM, 6. L 613

EXPORT HOUSE requires
EXECUTIVE FOR ENGINEERING DEPARTMENT able to handle negotiations at commercial level. Engineering qualifications preferred but not essential. A splendid opportunity for man with initiative and commercial ability. West End offices. —Please apply BOX L 630, Offices of ENGINEERING.

Leading manufacturers of container closures in the Midlands have a numbes of vacancies for ambitious DESIGN DRAUGHTSMEN preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation. Write in confidence with details of experience, positions held, salary required, to P.A. METAL CLOSURES LIMITED, BROMFORD LANE, WEST BROMWICH. G 627

Unfurnished Flats available

in attractive town convenient to London and East Coast for ambitious and enthusiastic engineers.

If you are an experienced—
Jig and tool Draughtsman
Design Draughtsman
Production Engineer

and anxious to join a vigorous, expanding organisation manufacturing electrical equipment—write to

THE PERSONNEL MANAGER,
WOODS OF COLCHESTER, LTD.,
BRAISWICK WORKS,
COLCHESTER.

An associate Company of The General Electric Co., Ltd. L 594

ASSISTANT CHIEF PROCESS ENGINEER required by leading Aircraft Engineering Company situated in the North West. Higher National Certificate in Mechanical Engineering is necessary. Applicants must be capable of analysing design; experienced in Process Planning and Tool Design. General Engineering background, with up to date experience in Mechanical Engineering and experience of aircraft production essential. Applicants should write giving full details of qualifications, experience, present salary and salary required, to BOX L 614, Offices of ENGINEERING.

ASSISTANT CIVIL ENGINEERS required on design side by Consultants in Westminster. Experience in (*a*) power station or (*b*) docks advantageous. Salary will be considered on qualifications and experience from £800 upwards if A.M.I.C.E. or similar.—BOX L 635, Offices of ENGINEERING.

This expanding organisation offers excellent opportunities for advancement to men with initiative who seek an interesting career with a really progressive firm.

SENIOR DESIGNERS, DEVELOPMENT ENGINEERS & DRAUGHTSMEN

should apply to the Technical Manager,

THE HYMATIC ENGINEERING CO., LTD.,

REDDITCH, WORCESTERSHIRE.

*

Experience is desirable in precision engineering, aircraft accessories, pneumatics or hydraulics, together with adequate technical training. L 664

WORK STUDY—ENGINEERS with degree or similar qualification and with experience in Job and Method Improvement or Time and Motion Study are required by Pilkington Brothers Limited, whose long-established Work Study Department is being expanded. Applications should give details of age, qualifications and experience and be addressed to the PERSONNEL OFFICE (STAFF), PILKINGTON BROTHERS LIMITED, ST. HELENS, LANCASHIRE. L 599

A SENIOR MECHANICAL DESIGNER DRAUGHTSMAN accustomed to work on intricate mechanisms is required by THE GENERAL ELECTRIC CO., LTD., Witton, Birmingham, 6.
This is a permanent appointment with salary according to qualifications. Please write with full particulars to The STAFF MANAGER. L 601

MECHANICAL-ELECTRICAL ENGINEER for post abroad, aged under 20, free house, good conditions, allowances and superannuation, excellent prospects; University or Technical College qualifications essential and experience in General Workshop practice. Must have good electrical knowledge.—Write giving details of education and experience. Write 0853 WM. PORTEOUS & CO., GLASGOW. L 609

ROAD ENGINEER required for Nigeria to carry out surveys, prepare schemes and specifications for road improvement schemes in large towns. Aged 25 to 35 years; preferably single; qualifications, A.M.I.C.E. or equivalent. Basic salary £1200 to £1500 per annum according to experience. 18 months tour, 3 months full pay leave; bonus of £225 on completion. Free passages each way; free transport and accommodation; free medical attention. Kit allowance. Please reply to BOX L 591, Offices of ENGINEERING, giving full details of experience and general background.

AERO ENGINE CONTROL SYSTEM.

ENGINEERS are required for a newly formed department dealing with various theoretical aspects of aero engine control problems. Experience of servo mechanism analysis and gas turbine engine performance investigation is desirable.—Applications quoting END to TECHNICAL PERSONNEL MANAGER, ARMSTRONG SIDDELEY MOTORS, COVENTRY. G 658

ROCKETS—TEST PLANT DESIGN AND DEVELOPMENT. ARMSTRONG SIDDELEY MOTORS require
ENGINEERS with a Degree or H.N.C. to design and develop Rocket propulsion experimental test equipment. This young division with its future is a worthwhile field both for interest and prospects.—Applications, quoting RTP, to TECHNICAL PERSONNEL MANAGER, ARMSTRONG SIDDELEY MOTORS, COVENTRY. G 659

THE G.E.C. STANMORE LABORATORIES require
ENGINEERS WITH H.N.C. OR DEGREE, with some knowledge of aircraft electrical work and preferably some experience of airborne equipment for planning the installation of radar equipment in aircraft. Applicants without the necessary academic qualifications but with considerable experience of this type of work will receive serious consideration.—Please apply, in writing, to the STAFF MANAGER, G.E.C. STANMORE LABORATORIES, THE GROVE, STANMORE, MIDDX., quoting ref. E/JT. L 485

DESIGNER, B.SC. ENG., for Scientific Instrument and Laboratory apparatus works at Mitcham, Surrey. Age 25-30. Range wide in interest and variety.—Write details experience and salary required to TECHNICAL DIRECTOR, GRIFFIN & GEORGE, LTD., EALING ROAD, ALPERTON, WEMBLEY, MIDDX. L 525

BRITISH THOMSON-HOUSTON CO., LTD.
There are vacancies in the Valve Engineering Department for work connected with the engineering and development of semi-conductor devices. Those with qualifications (H.N.C. and above) in electrical engineering or physics are wanted for development projects involving transistors and rectifiers; an interest in radio would be an advantage. Qualified Mechanical Engineers (H.N.C. and above) are needed to design and develop jigs and automatic machines for device manufacture.
Applicants are invited to write to the HEAD OF THE VALVE ENGINEERING DEPARTMENT, BRITISH THOMSON-HOUSTON CO., LTD., LADYWOOD WORKS, LUTTERWORTH, NR. RUGBY, giving details of their age, qualifications and experience. L 573

DRAUGHTSMAN required for Engineering Department of modern Tar Distillery. Applicants should be of at least O.N.C. Standard with General Engineering experience, preferably including plant layout and piping. Varied and interesting work, including some site work. Pension scheme. Salary up to £750 per year. Interviews may be arranged on Saturday mornings if desired.—Apply to CHIEF ENGINEER, LANCASHIRE TAR DISTILLERS, LTD., LIVERPOOL ROAD, CADISHEAD, NR. MANCHESTER. Tel.: Irlam 2001. L 496

A large Industrial Organisation has a vacancy for a **QUALIFIED MECHANICAL ENGINEER,** aged 30-35, with good social and educational background, to train as a specialist, finally to take charge of staff probably situated in the Yorkshire area.—Reply, stating full details of age, qualifications and experience to BOX L 506, Offices of ENGINEERING.

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Experimental Physicists with Honours Degrees in Classical Physics,

Experimental Physicists holding H.N.C. or G.C.E.

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Men holding Honours or Pass Degrees in Mechanical Engineering with some experience in industry. In addition there are vacancies for assistants holding H.N.C. in Mechanical Engineering and who have served an apprenticeship.

DESIGNERS

Men having design experience, and holding Honours or Pass Degrees in Mechanical Engineering, and having practical experience, preferably in Marine Engineering, or on the technical side for the generation of power for use on land.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes.

Applications, giving full details, should be sent to the above address. L 524

VICKERS-ARMSTRONGS (ENGINEERS) LIMITED
BARROW-IN-FURNESS, LANCASHIRE

Are seeking technical staff, as under, for research and development work in connection with the application of new methods to the propulsion of ships.

ENGINEERS

Engineers holding Honours Degrees with experience in the field of marine or mechanical engineering.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes, and the production and installation of machinery.

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For marine research work. A minimum standard of H.N.C. is required, and sea-going experience with Board of Trade Certificate will be a distinct advantage.

The above requirements offer a splendid opportunity to the right type of men, and good salaries will be paid in accordance with experience, ability and training.

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Applications giving full details, should be sent to the Labour Manager at the above address. L 642

ENGINEERING ASSISTANT required by Consulting Engineers. Qualifications—H.N.C. standard or equivalent. Experience required—apprenticeship with Structural Engineers and capable of steel work design.—APPLY SIR BRUCE WHITE, WOLFE BARRY & PARTNERS, 1, LYGON PLACE, S.W.1. SLOane 0431. L 673

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ASSISTANT CIVIL ENGINEERS required for important development work in heavy industry. Ability to take complete control of sections of work essential. Please state experience and salary requirements.—Apply to BOX L 571, Offices of ENGINEERING.

Classified Advertisements continued on Page 146

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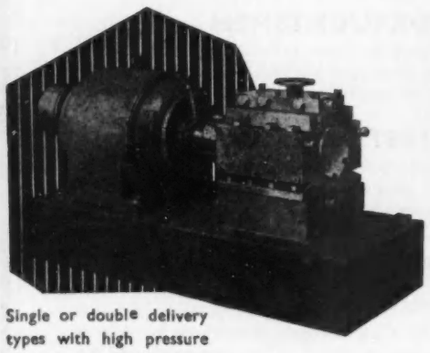

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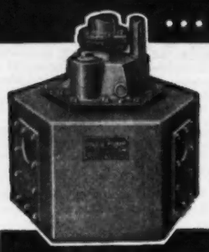

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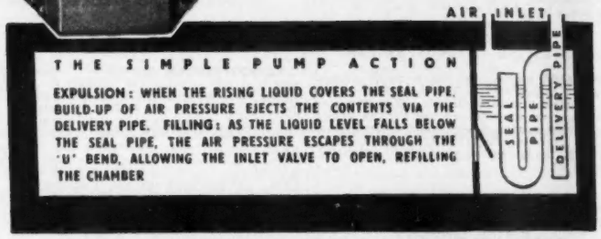

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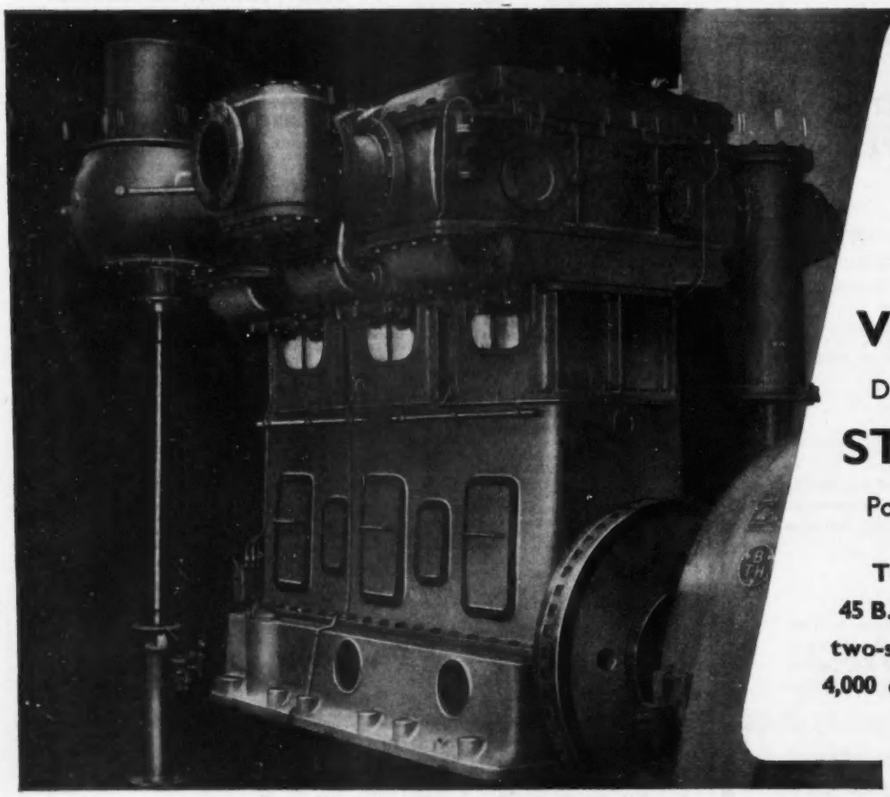

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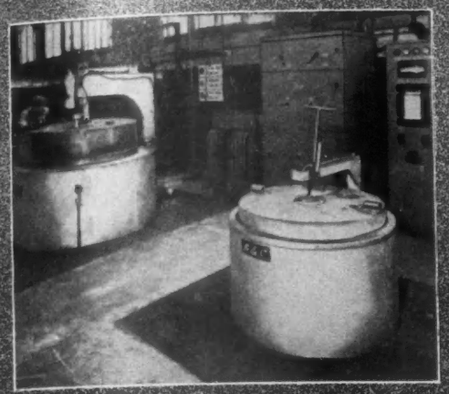

G.E.C. batch type carburising furnace and cooling chamber.

At their Elswick and Scotswood Works, Vickers-Armstrong (Engineers) Ltd., have recently installed two batch furnaces with separate cooling chambers—for gas carburising gear wheels—and a continuous hardening furnace with a roller hearth.

The processing atmospheres in the furnaces are generated from a liquid mixture introduced by a drip-feed technique.

The furnaces were designed and supplied by the General Electric Co. Ltd., who also developed the special fluid used for generating the atmospheres.

A charge of gear wheels being removed from the cooling chamber.

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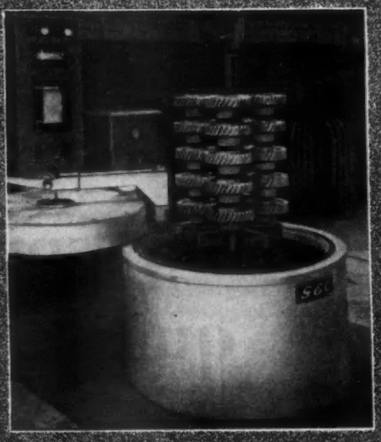

A gear being removed from the roller hearth furnace for quenching.

For efficient process heating use

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NP.33

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strong as glass

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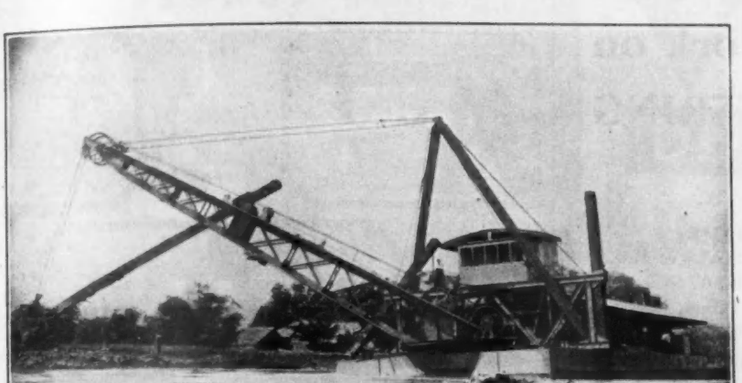

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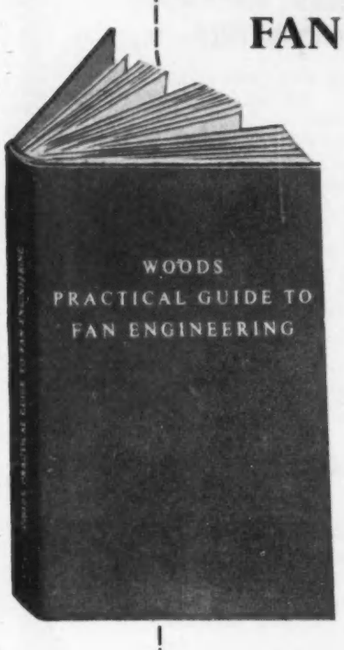

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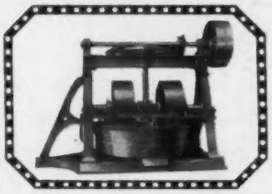

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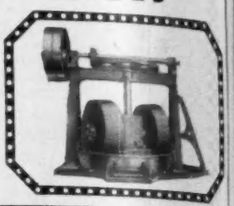

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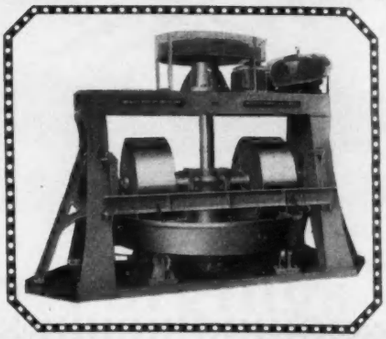

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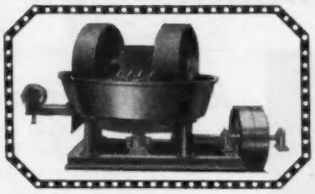

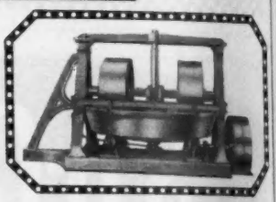

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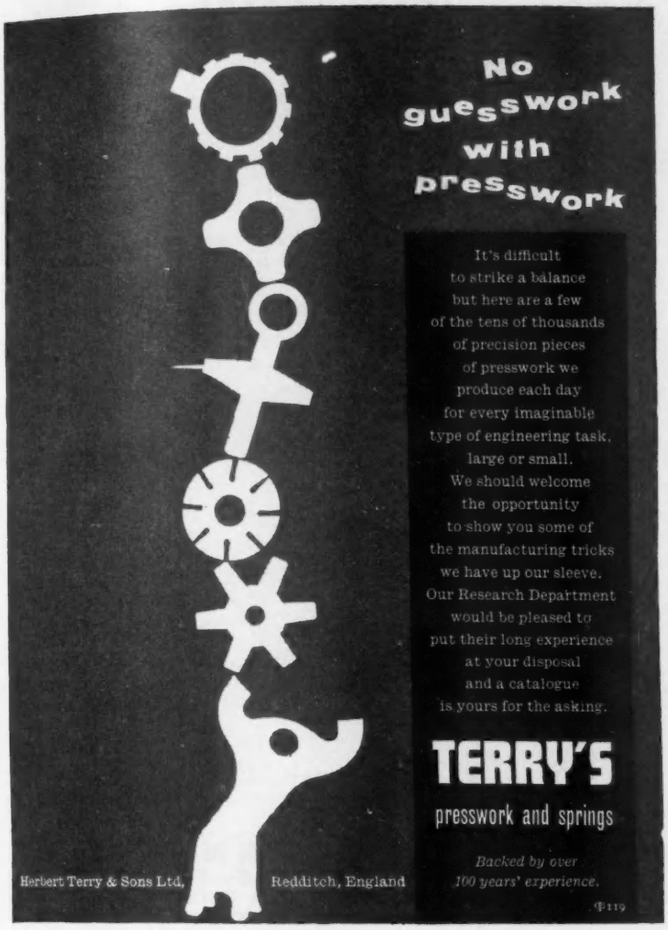
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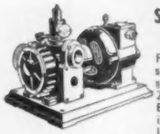

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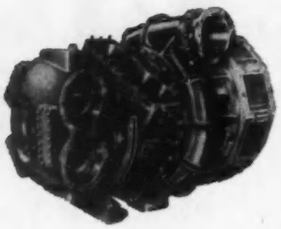

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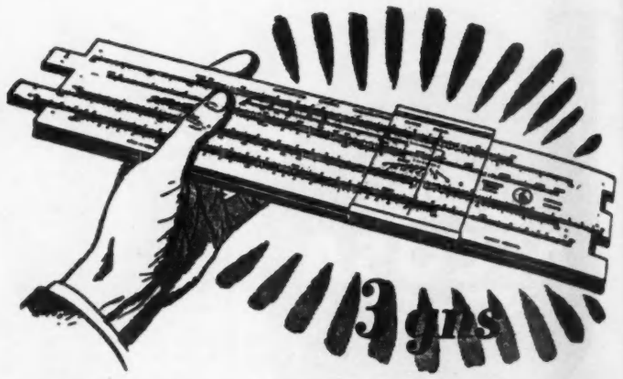

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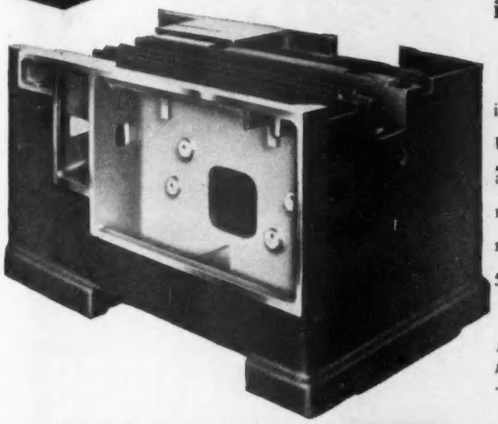
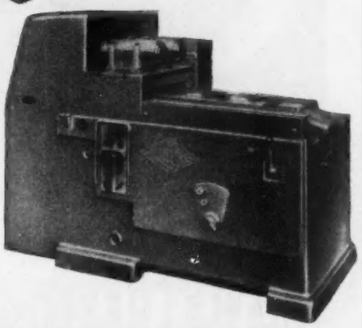


We manufacture iron castings by both the mechanised and floor moulded methods. Maximum unit weight: 5 tons.

Illustrations by permission of John Lund Ltd.



Q & S Grey Iron Castings are used where only the best is good enough. That is why John Lund Ltd. specify them for use in the construction of their *Precimax* Fine Boring Machines. The illustration above shows a body casting for a *Precimax* Single-ended Fine Boring Machine, and the smaller illustration at right shows a completed machine.

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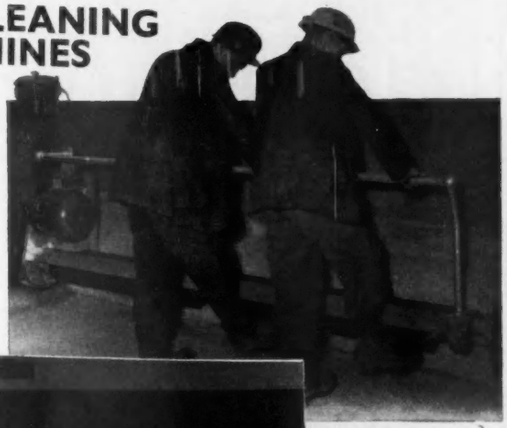

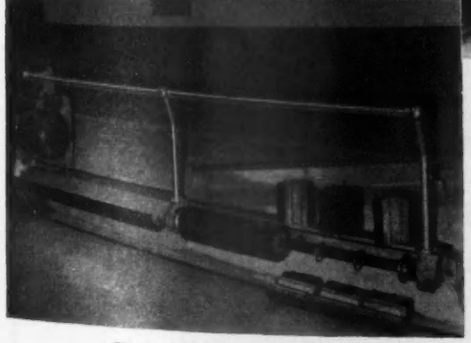

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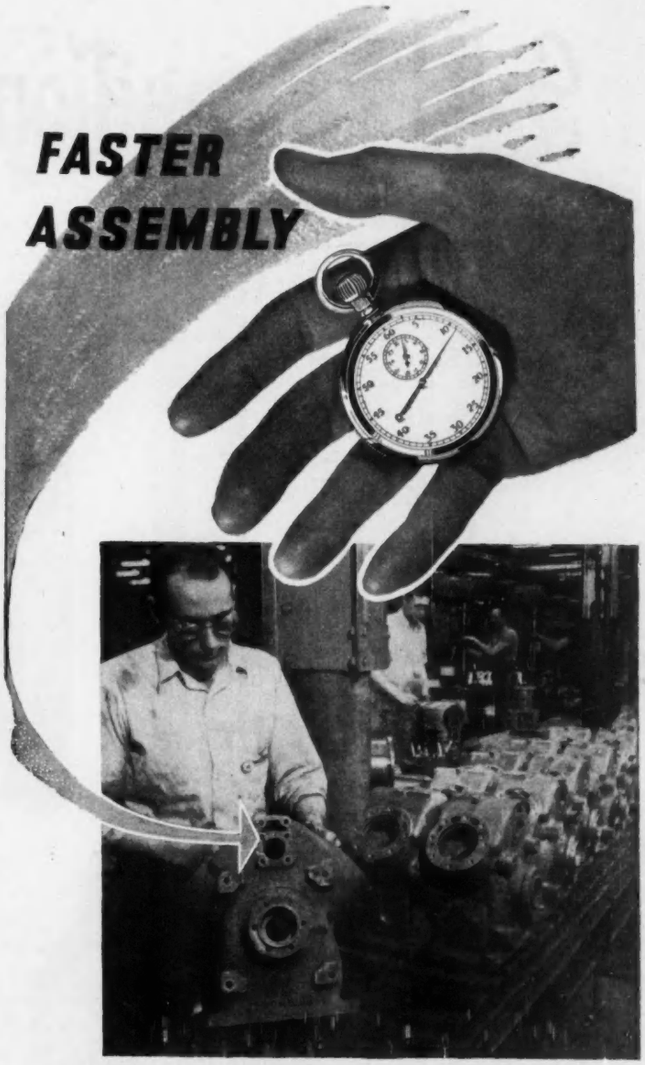
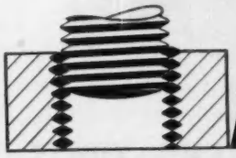


WITH...



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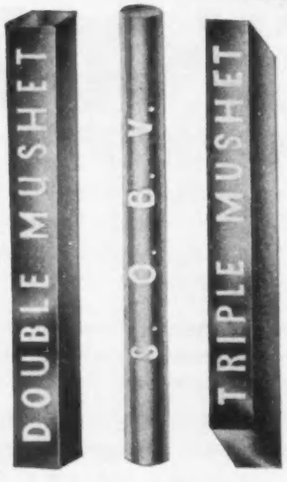

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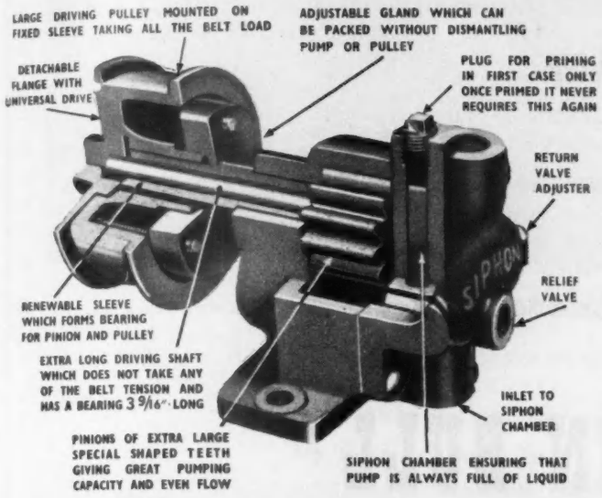
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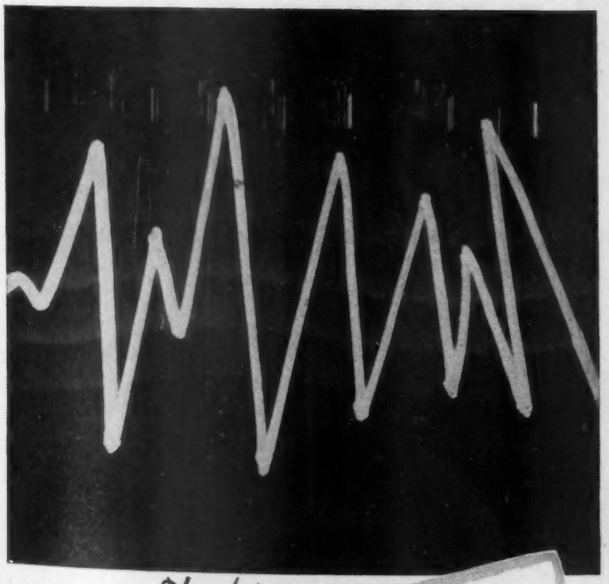

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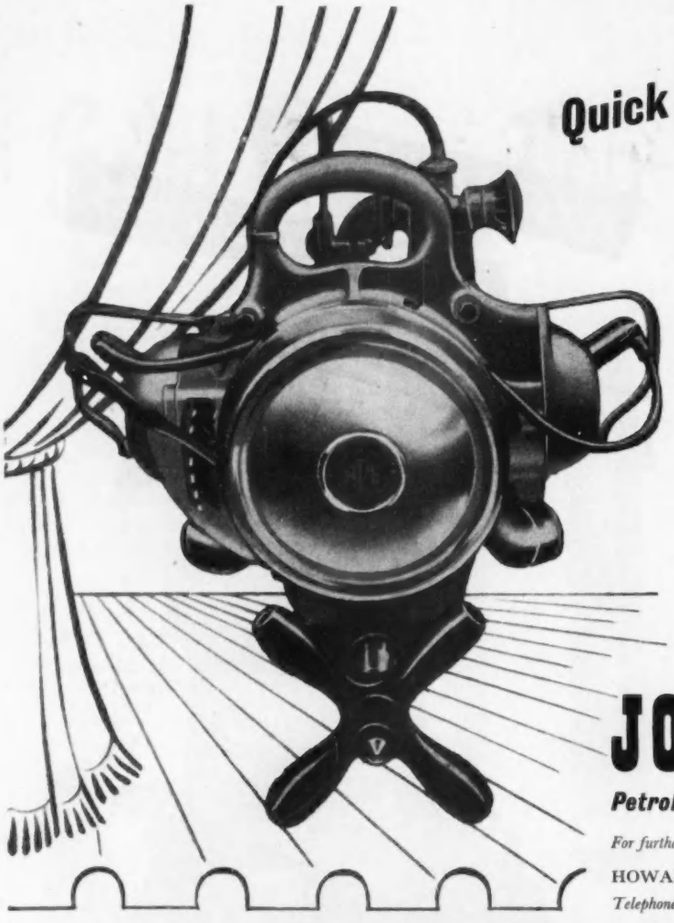

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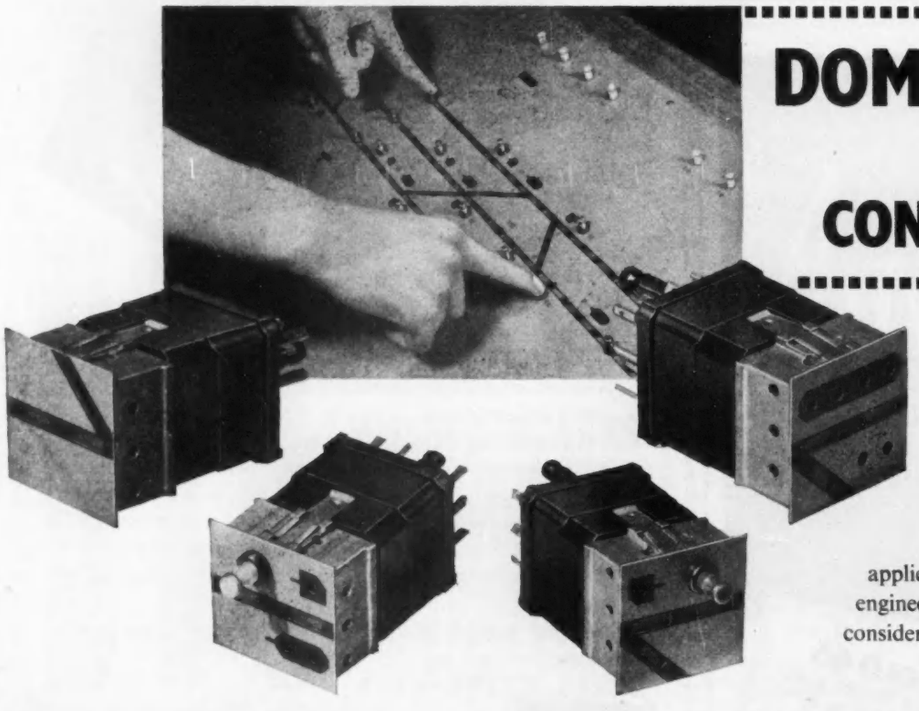

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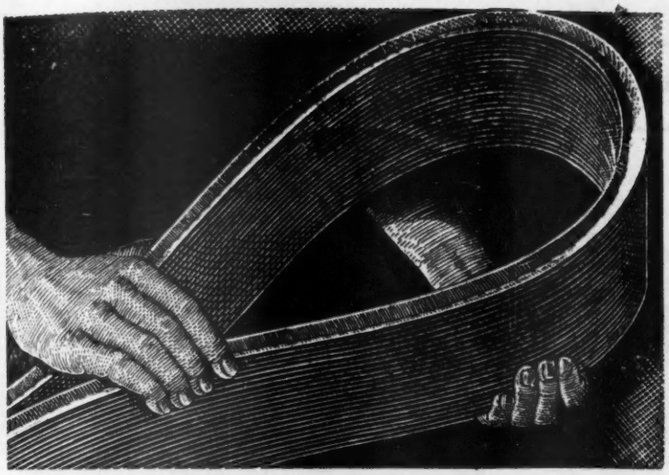

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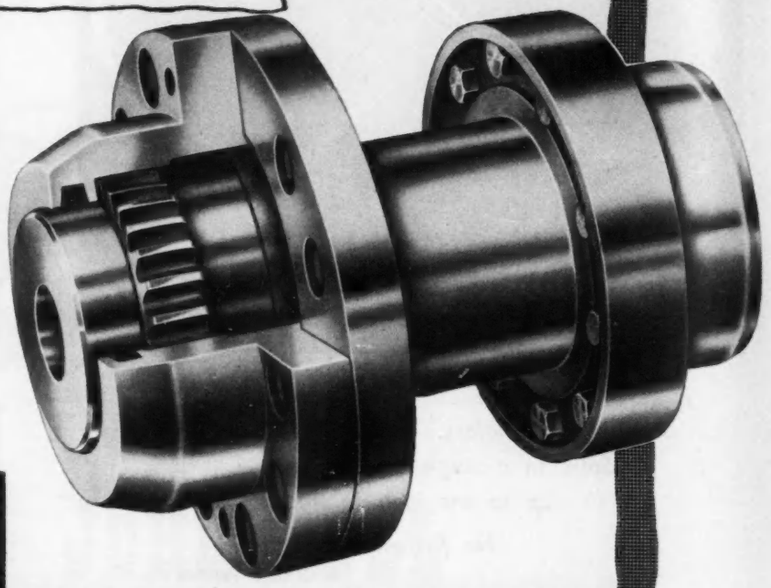

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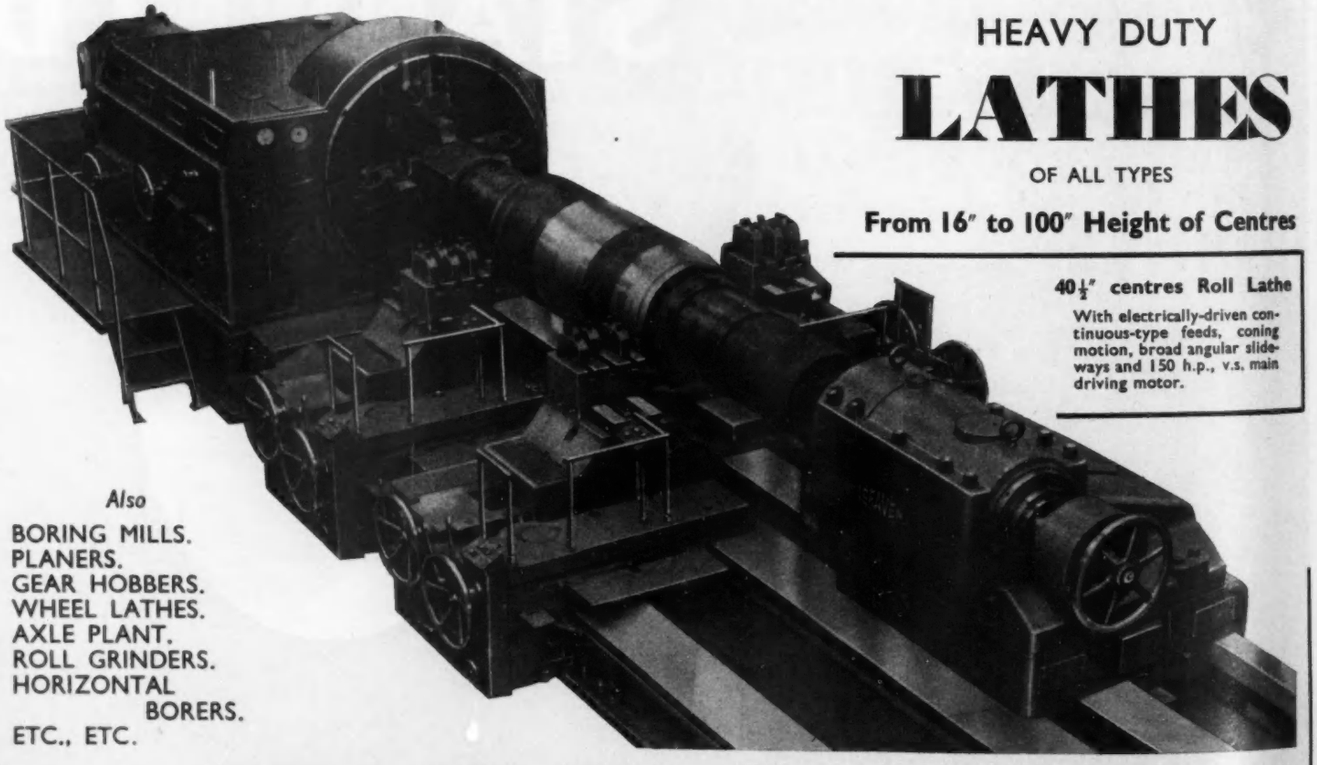

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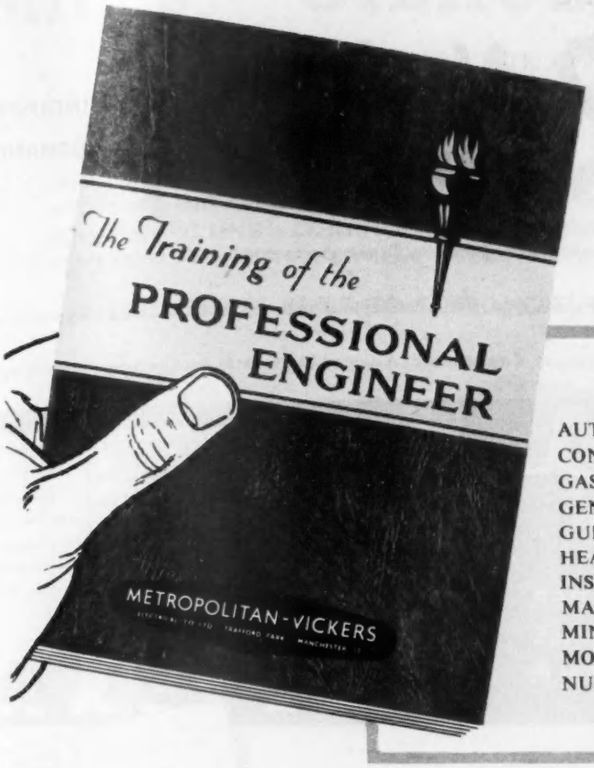

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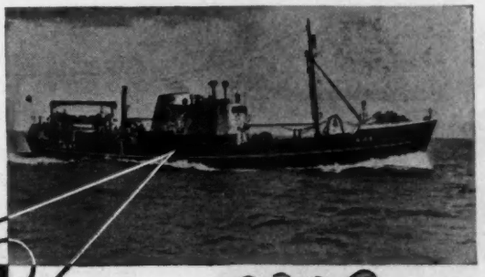

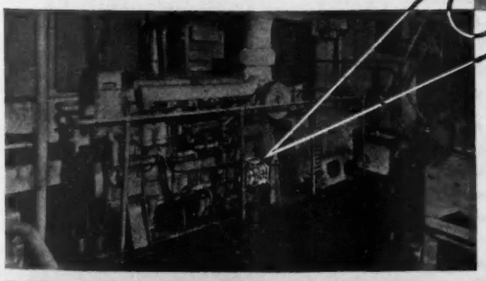

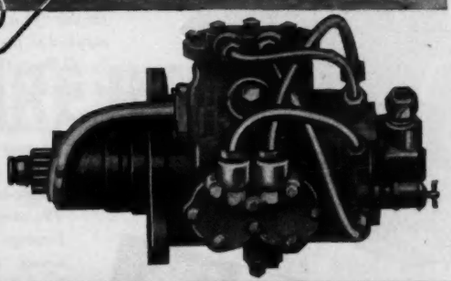

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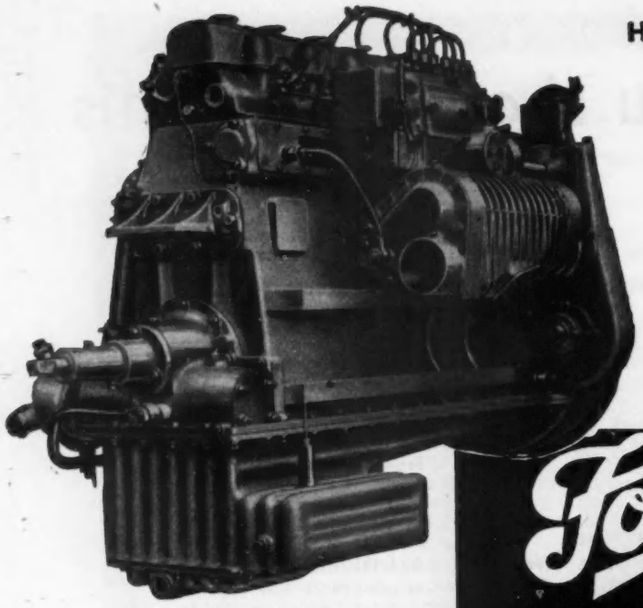

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B.M.E.P. at 1800 r.p.m.	93 lbs./sq. in.
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Piston speed at 1800 r.p.m.	1417 ft. min.
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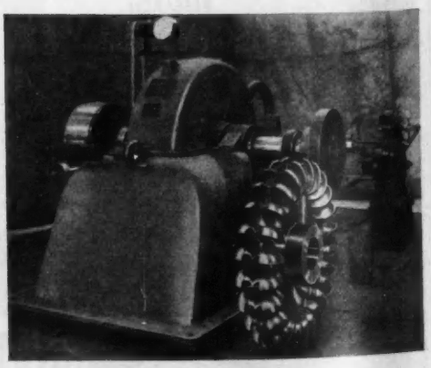

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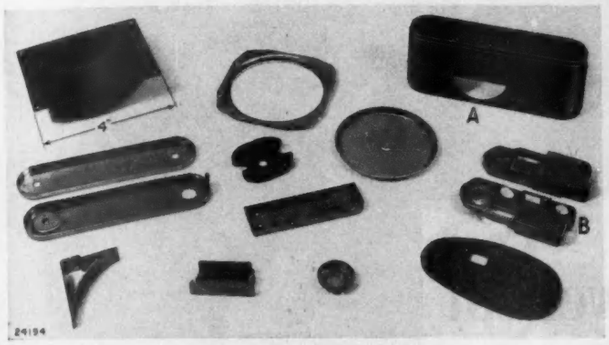

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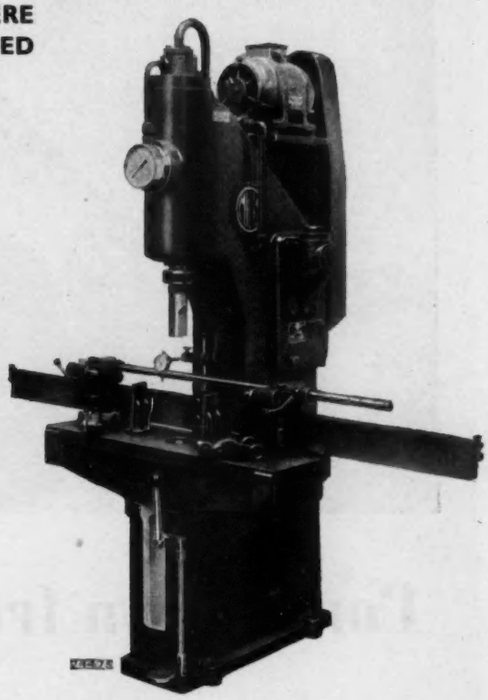

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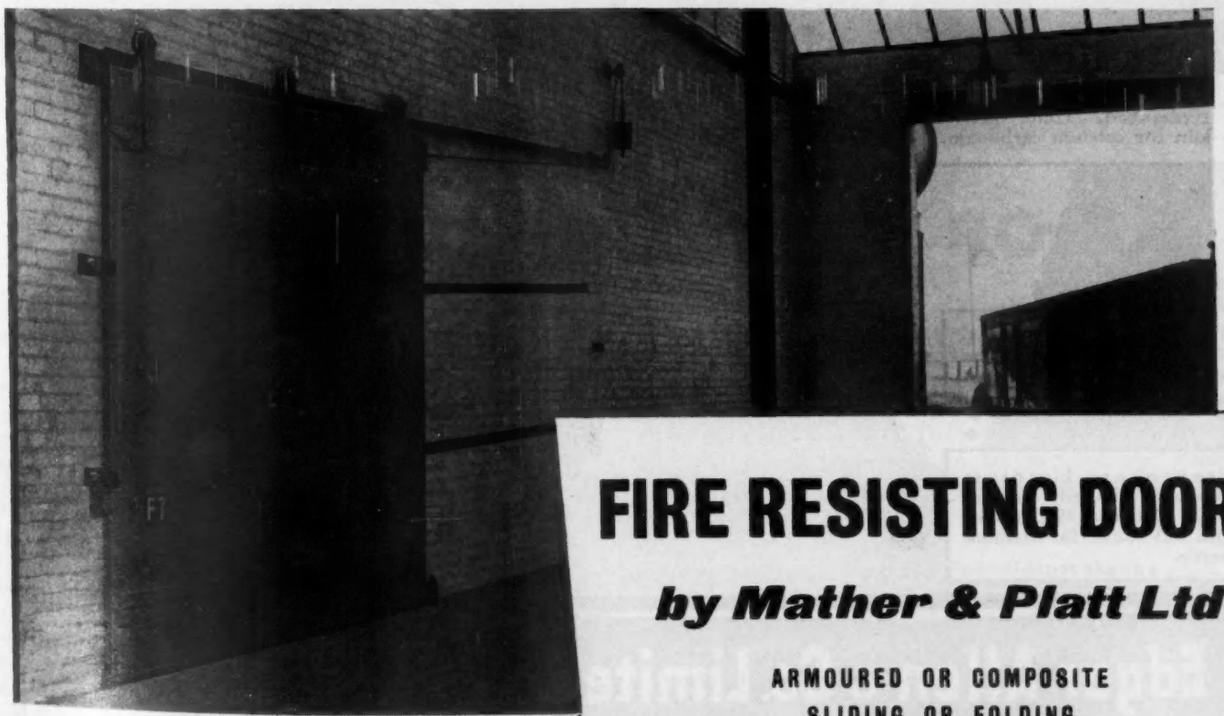

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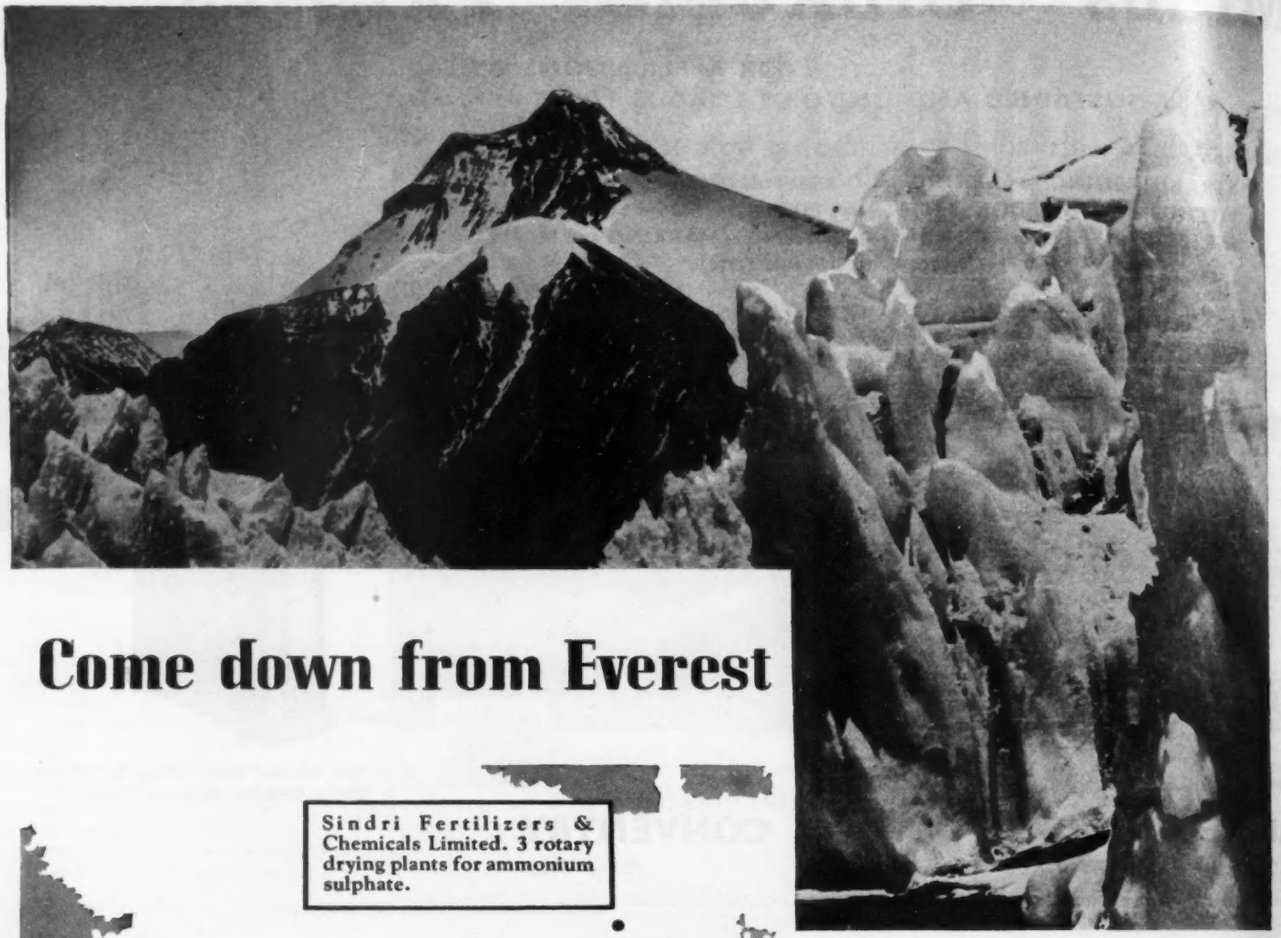
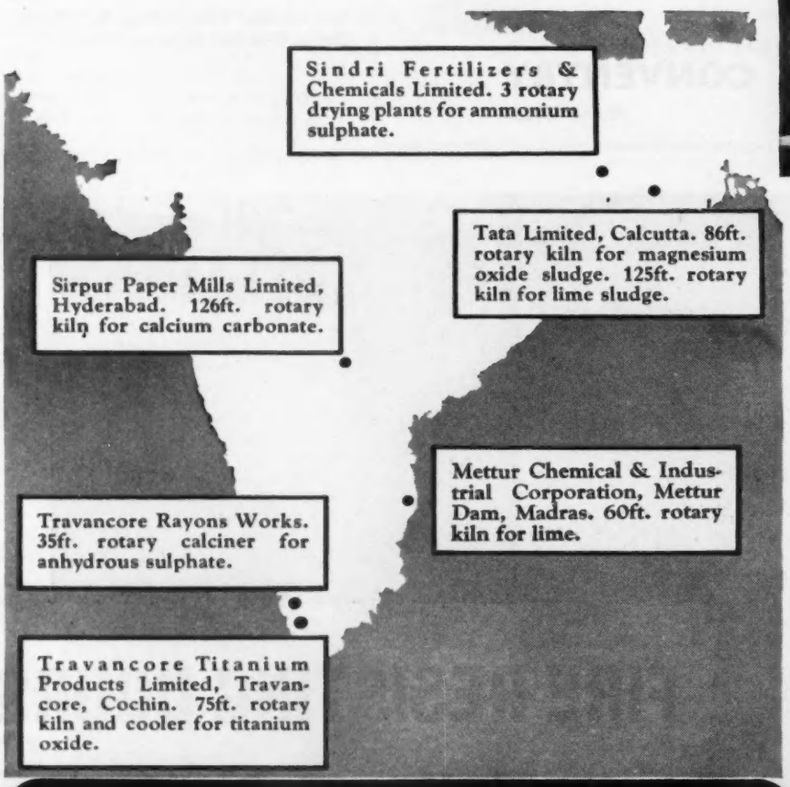


Come down from Everest


Sindri Fertilizers & Chemicals Limited. 3 rotary drying plants for ammonium sulphate.
Tata Limited, Calcutta. 86ft. rotary kiln for magnesium oxide sludge. 125ft. rotary kiln for lime sludge.
Sirpur Paper Mills Limited, Hyderabad. 126ft. rotary kiln for calcium carbonate.
Mettur Chemical & Industrial Corporation, Mettur Dam, Madras. 60ft. rotary kiln for lime.
Travancore Rayons Works. 35ft. rotary calciner for anhydrous sulphate.
Travancore Titanium Products Limited, Travancore, Cochin. 75ft. rotary kiln and cooler for titanium oxide.

. . . down to the teeming plains of India and Pakistan, where one of the most momentous industrial revolutions of modern times is taking place. A vast country is slowly transforming itself to give a higher standard of living to its peoples.

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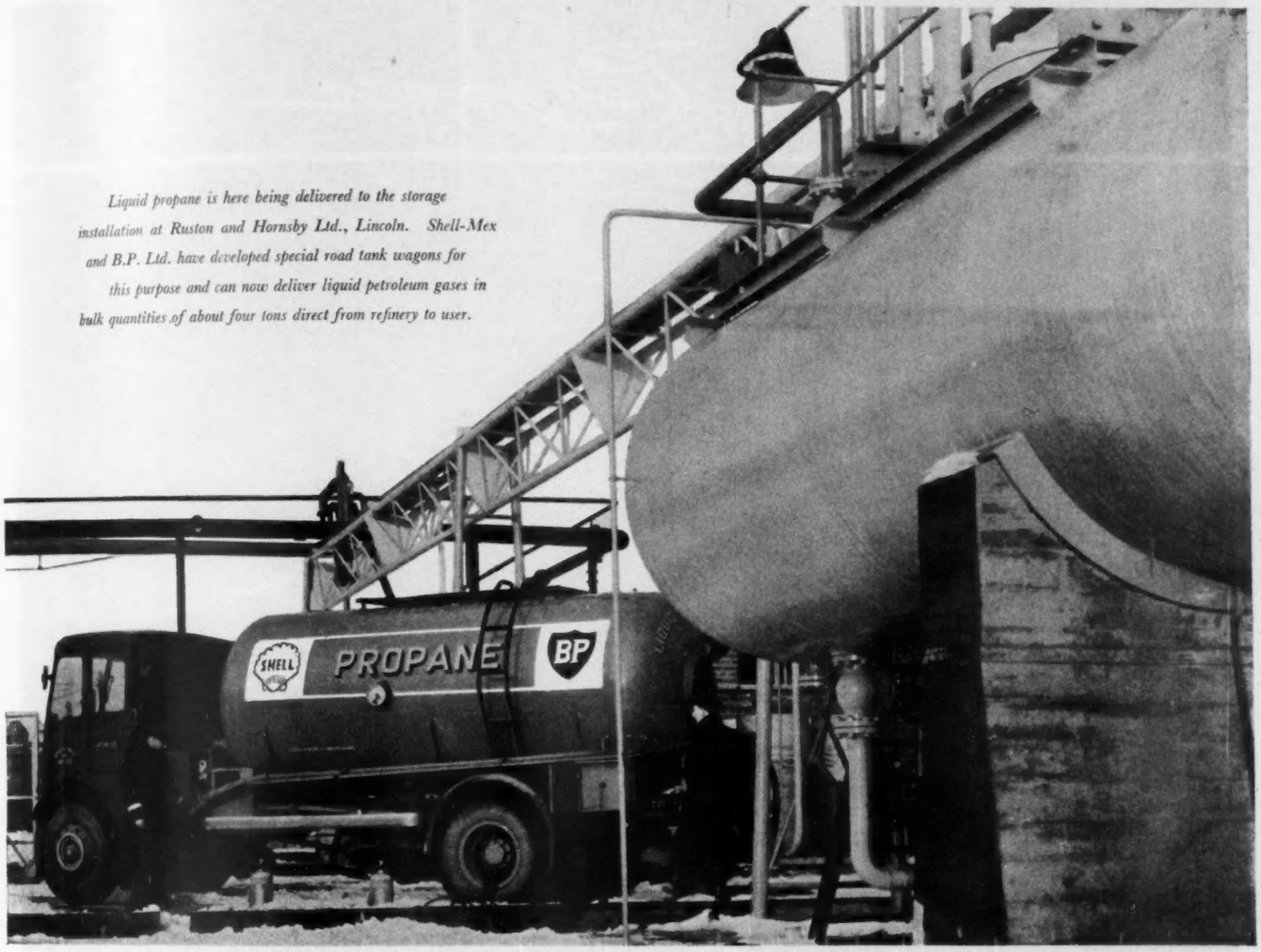


Liquid propane is here being delivered to the storage installation at Ruston and Hornsby Ltd., Lincoln. Shell-Mex and B.P. Ltd. have developed special road tank wagons for this purpose and can now deliver liquid petroleum gases in bulk quantities of about four tons direct from refinery to user.

Bulk delivery of LIQUID PROPANE BY ROAD

Ruston & Hornsby's new Gas Turbine Test Shop at their Lincoln Works has to deal with turbines developed to run on a wide variety of fuels—solid, liquid and gaseous. Those designed to run on natural and other gas are tested on commercial propane supplied by Shell-Mex and B.P. Ltd., a simple statement of fact that hides a wealth of engineering ingenuity.

Each wagon carries 4 tons of Propane

Propane is produced during the refining of crude petroleum and is a gas at normal temperatures and pressures. It can be readily liquefied under moderate pressures in the order of 100-200 lb./sq. in. Liquid propane is delivered to the Ruston & Hornsby Turbine Test Shop in bulk by road tank wagon. The wagons used for this purpose have a tank made to " Class 1 " unfired pressure-vessel specification and carry about 1800 gallons (approximately 4 tons of propane). The liquid propane is off-loaded by pump, measured through a liquid meter and transferred to the storage tanks through fire resisting flexible armoured hose that is fitted with Lockheed-Avery Self-Sealing Couplings.

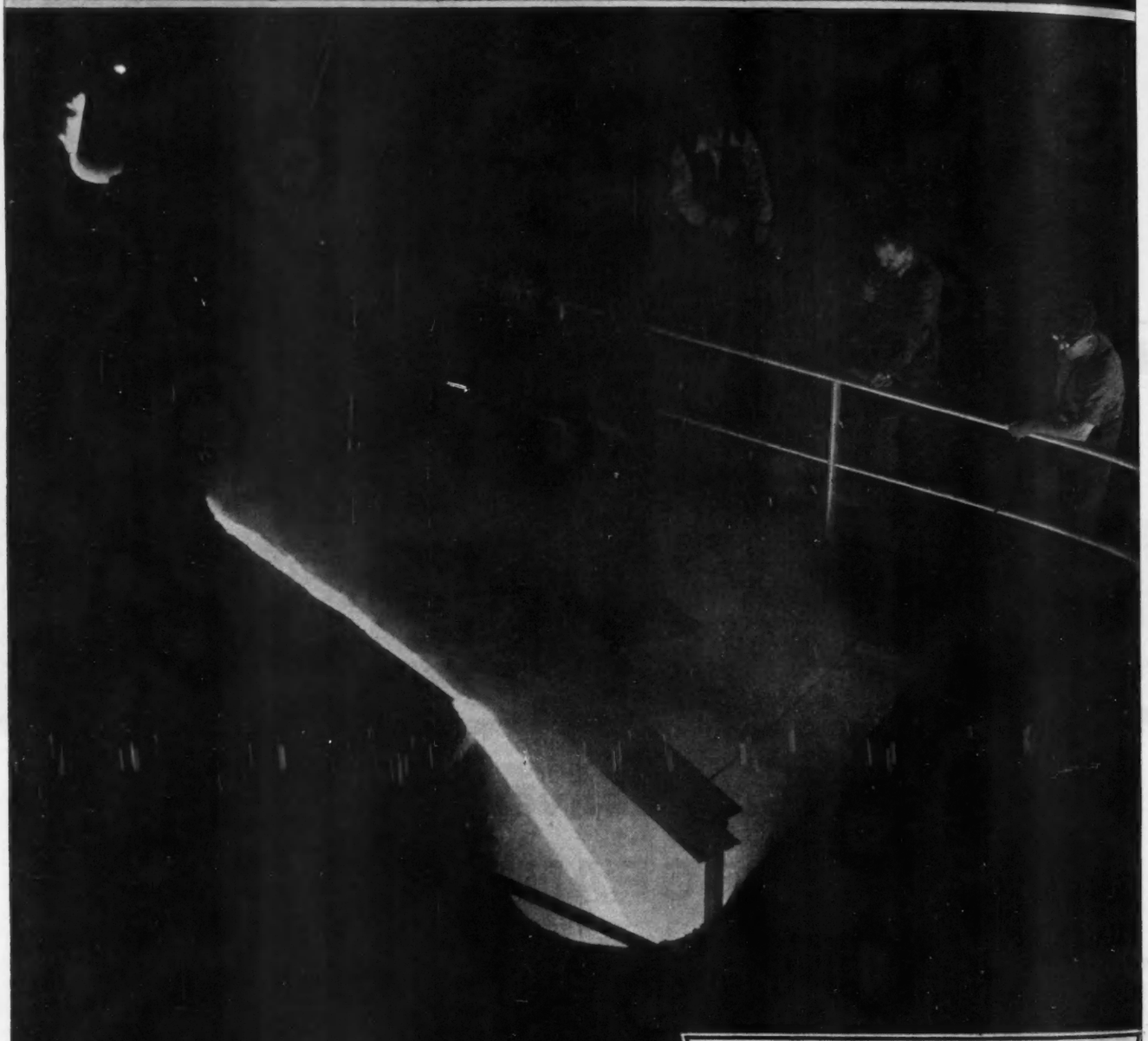
Automatic Regulation of Gas-Air Mixtures

Ruston's storage installation consists of two tanks each of 12½ tons propane capacity. A steam heated vaporiser provides the latent heat of vaporisation and so makes possible the evolution of large volumes of high-pressure gas in a short space of time. The gas and compressed air are automatically regulated and then mixed to give gas-air mixtures at any predetermined value between 600 and 1200 B.Th.Us. /cu. ft. A sample of the gas-air mixture is reduced to constant low pressure and burned in a recording B.Th.U. meter to give a visual indication of the mixture's calorific value.

Advantages of Liquid Petroleum Gases

Once again, Ruston & Hornsby are pioneering a new technique, and many other manufacturing concerns are now investigating the use of liquid propane for all manner of specialised furnace and industrial heating applications. Delivered in bulk, liquid petroleum gases are an economic proposition for many such applications. The high degree of purity, freedom from sulphur and other unwanted contaminants, constant properties and—above all—the security offered by a stock of gas on the premises, are considerable advantages. If you have an industrial gas problem on your hands, you cannot do better than write to Shell-Mex and B.P. Ltd., Liquid Gas Section, Shell-Mex House, Strand, London, W.C.2. This will place you under no obligation.

Parker Progress



New Electric Furnaces double steel output

From your first contact with Parker Foundry you experience a personal attention and an interest in your design problems that is indeed refreshing in these days of "take it or leave it". To this understanding service Parker now add greatly increased production facilities. New machines, new processes and 25,000 sq. ft. of extra floor space, now help to make even better castings, faster. The new electric furnaces for instance have 9" dia. electrodes and transformer capacity of 2,500 kVo — to permit optimum melt control.

They double the production of low carbon steel of high magnetic permeability, and pearlite manganese steel of high tensility and exceptional wearing characteristics. *Always Consult Parker first, before you finalise on steel castings.*

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steel castings

Manganese, Carbon & Alloy Steel.

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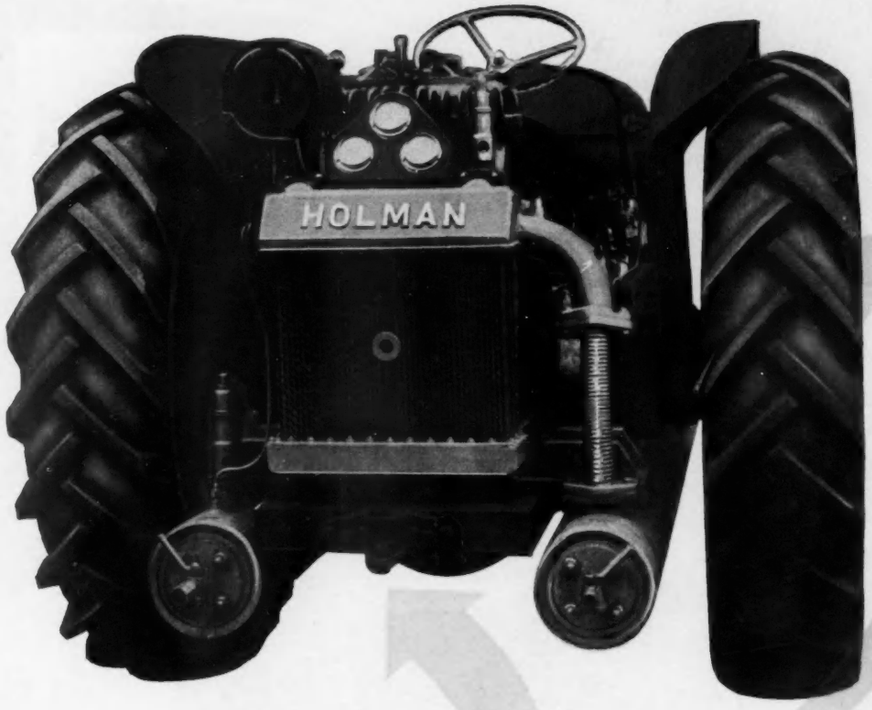
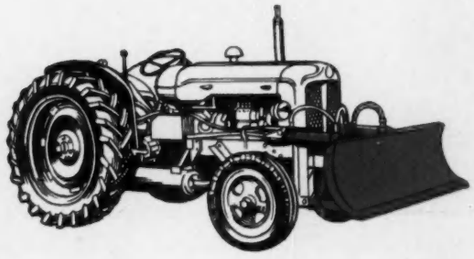


This is MOBILE POWER!

Depend on the ruggedly-built TRACTAIR to take the roughest going in its stride—to carry power to every site, however inaccessible. The TRACTAIR 13 incorporates a two-stage Holman compressor (FAD 110 cu. ft./min.) capable of operating at full pressure a range of Holman pneumatic tools which includes Picks and Road Rippers, Rammers, Spaders, Handrils and Rotopumps. May we send you full details?

The TRACTAIR's all-round usefulness is enormously increased by a range of accessories which includes this **hydraulically-operated Muledozer.**



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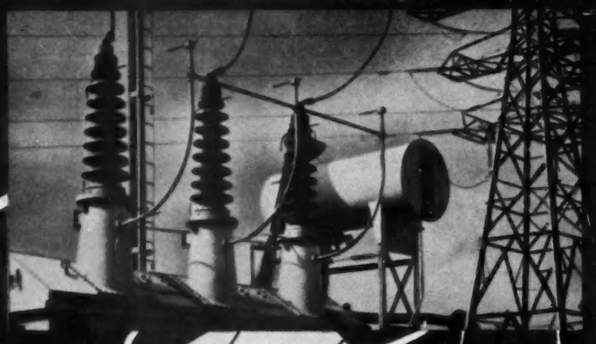

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turbo generators and transformers
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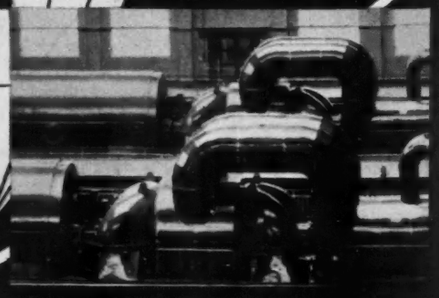

Sooner or later *you will come across something that could be made lighter, more durable, or more quickly and economically in aluminium. That's the moment to talk it over with an experienced man from*

Northern Aluminium

Let the wagons roll!

Across the countryside of Canada these new, all-welded, aluminium hopper wagons are proving their higher carrying capacity for the Roberval and Saguenay Railway. Twenty-eight of them were built recently to carry a total load of 2,430 tons—thirty comparable orthodox wagons, each some 5 tons greater in empty weight, would have been needed to do the same job.

Aluminium has proved itself both here and abroad to be exceptionally durable for carrying abrasive loads, and its long maintenance-free life gives it great advantages as a wagon-body material. With recent advances in welding techniques, fabrication is swift and simple.

Perhaps aluminium's combination of lightness and durability can provide an answer to your particular problem. If so, our Sales Development Division at Banbury, Oxon., will be pleased to discuss it with you.

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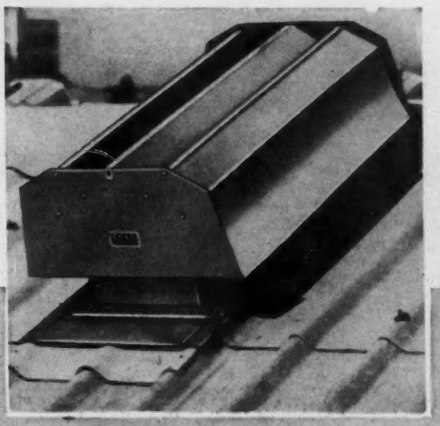
COLT Ventilation right from the start at...

A. E. C. SPARES BUILDING, Southall, Middlesex

ARCHITECT: HARRY W. WEEDON, F.R.I.B.A. & PARTNERS

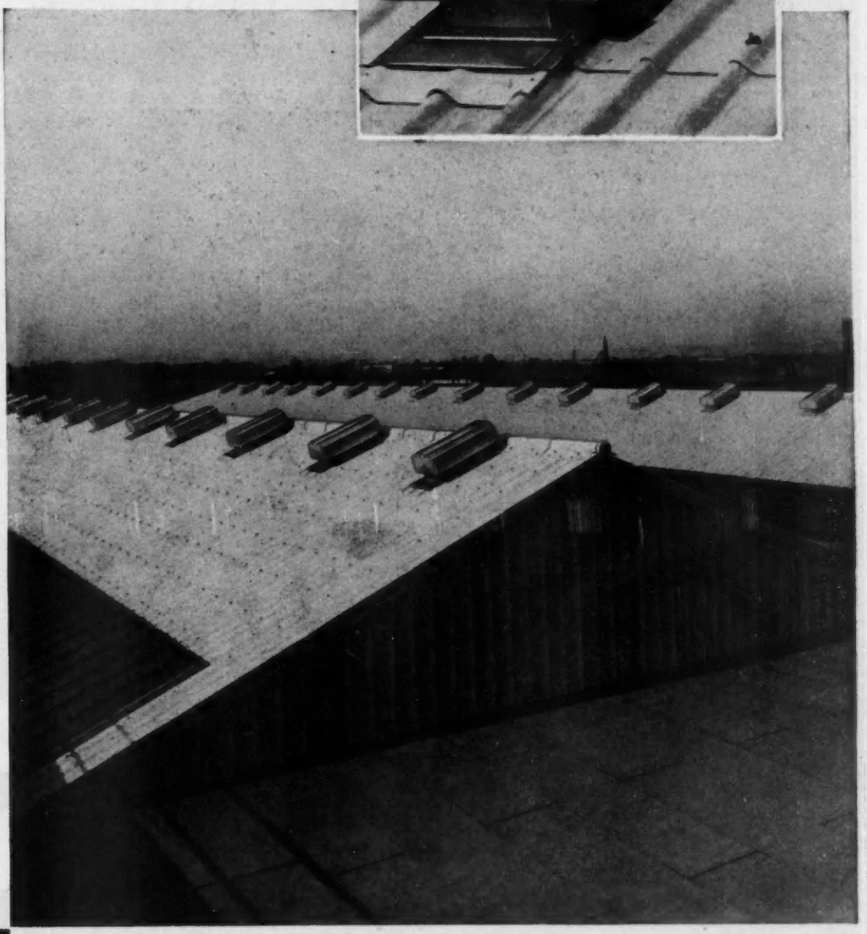


For the New Spares Stores for A.E.C. Ltd., the Architect required a natural system of ventilation to extract 3,000,000 cubic feet of air per hour from the building when desired. Control to facilitate the reduction of this rate of ventilation was also essential. Colt were consulted and a scheme involving the installation of 32 SRC/2046 Gear Controlled Ventilators was formulated and subsequently incorporated in the design of the building.

Of robust construction, and yet remarkably light, this High Duty Natural Roof Extractor incorporates aerofoil curves which harness the wind and roof eddies to combine with the power of convection within the building. It is maintenance free, and simple to install. One very notable feature is its appearance! When fixed in the roof it is quite unobtrusive.

Colt's wide experience in ventilating all types of buildings throughout industry is at your disposal. Whether the ventilation problem is large or small—in an existing building or for one still 'on the drawing board'—consult them first.

WRITE FOR FREE MANUAL with full specifications of Colt Ventilators to Dept G.57/243



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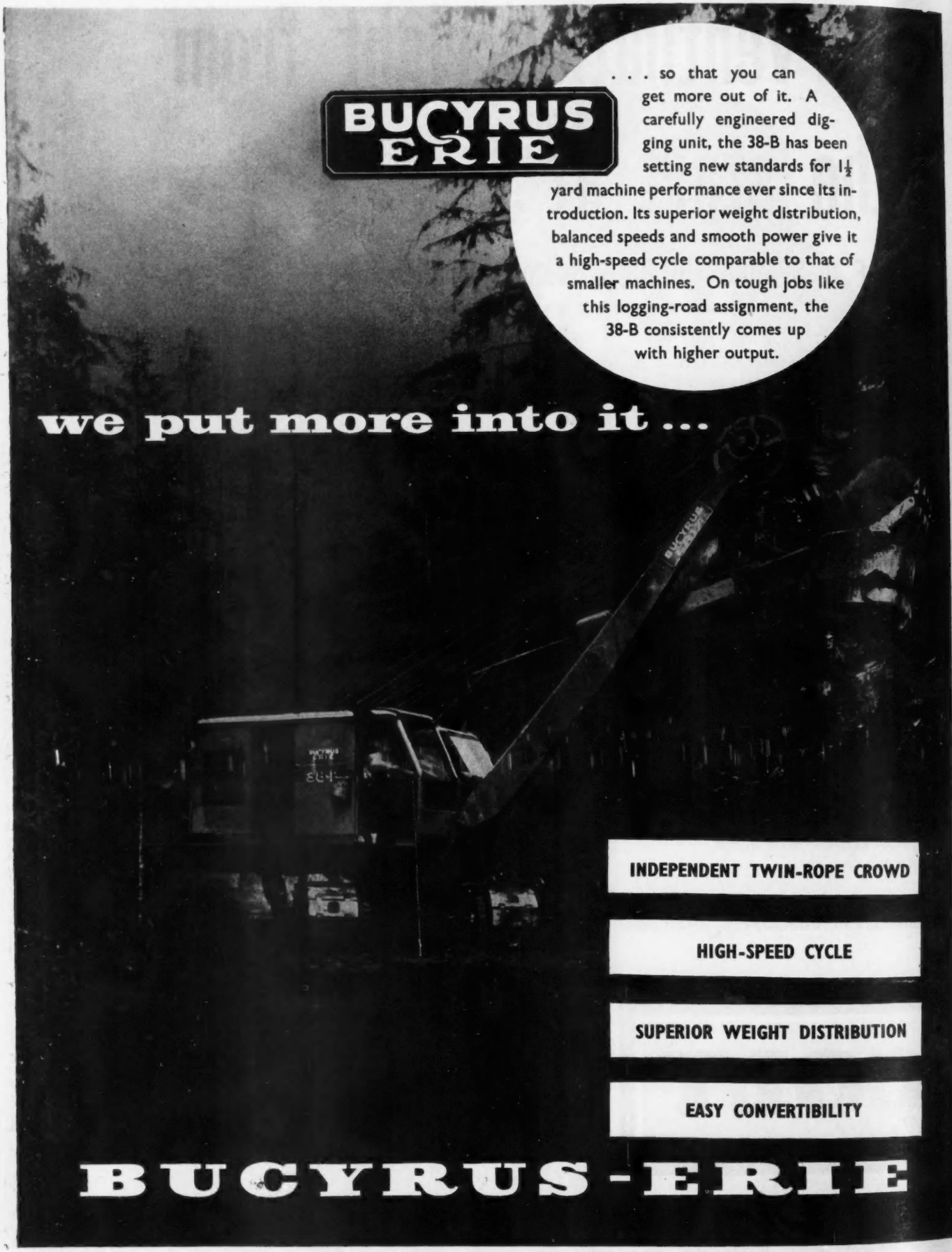
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. . . so that you can get more out of it. A carefully engineered digging unit, the 38-B has been setting new standards for 1½ yard machine performance ever since its introduction. Its superior weight distribution, balanced speeds and smooth power give it a high-speed cycle comparable to that of smaller machines. On tough jobs like this logging-road assignment, the 38-B consistently comes up with higher output.
we put more into it ...
INDEPENDENT TWIN-ROPE CROWD
HIGH-SPEED CYCLE
SUPERIOR WEIGHT DISTRIBUTION
EASY CONVERTIBILITY
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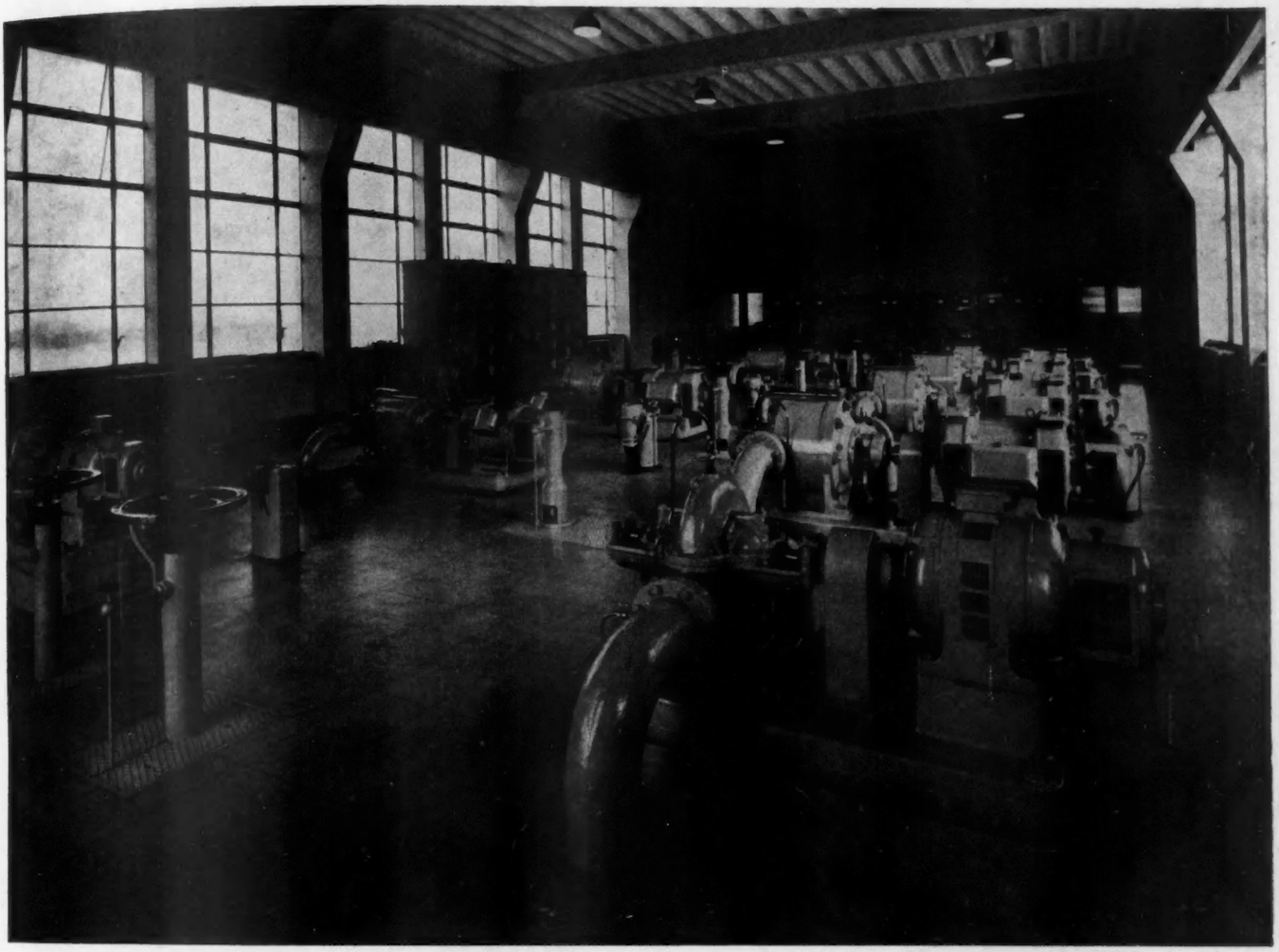

Stowey Pumping Station in which are installed 9 SULZER Centrifugal Pumps absorbing 599 B.H.P., having a capacity of 10·4 million gallons per day.

In connection with the CHEW VALLEY scheme of the BRISTOL WATERWORKS COMPANY
(R. W. Melvin General Manager)

a total of 24 SULZER PUMPING UNITS have been supplied including plant for the following

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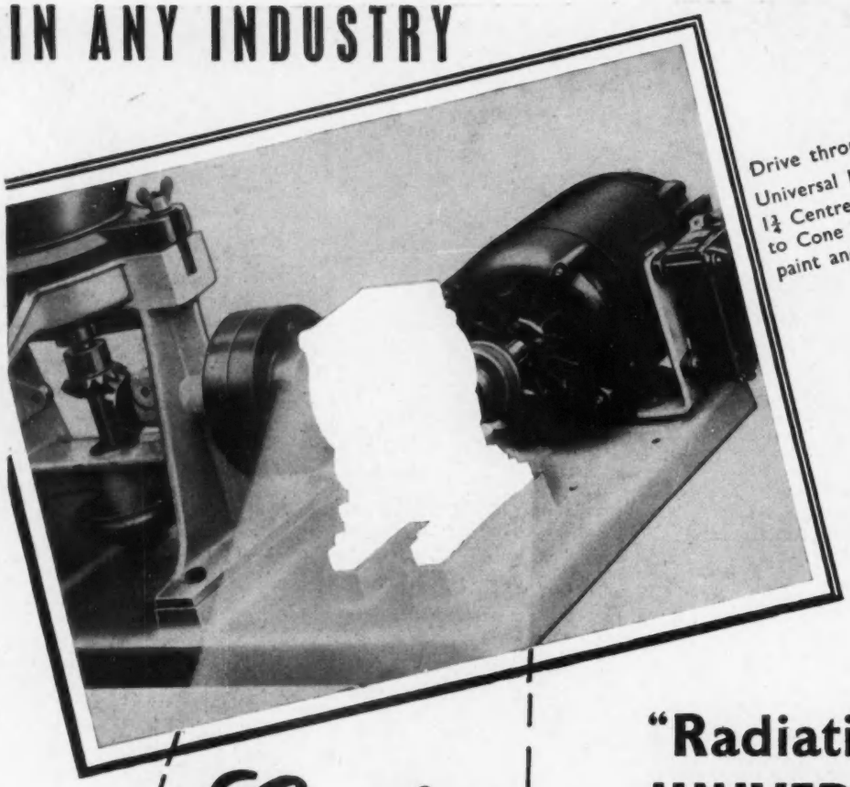
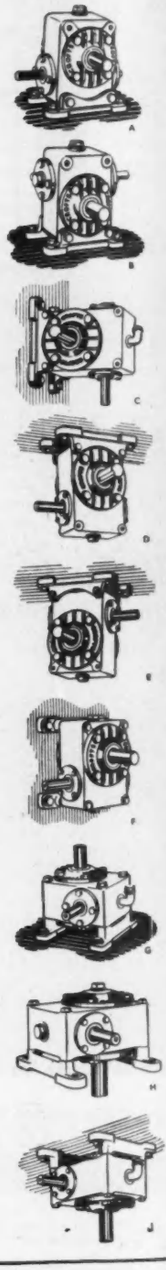


Drive through Crofts Universal Mounting Worm Gear, 1¾ Centres and Flexible Coupling, to Cone Grinding Mill for paint and ink trade.

ALTERNATIVE FOOT MOUNTING POSITIONS



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"Radiation" UNIVERSAL MOUNTING WORM REDUCTION GEARS COMPLETE THE PICTURE

The ideal Worm Reducer for small power applications up to 2½ H.P. Ratios 5 - 1 up to 60 - 1. Standard, Vertical & Inverted units FROM STOCK. Adaptable for every possible mounting position.

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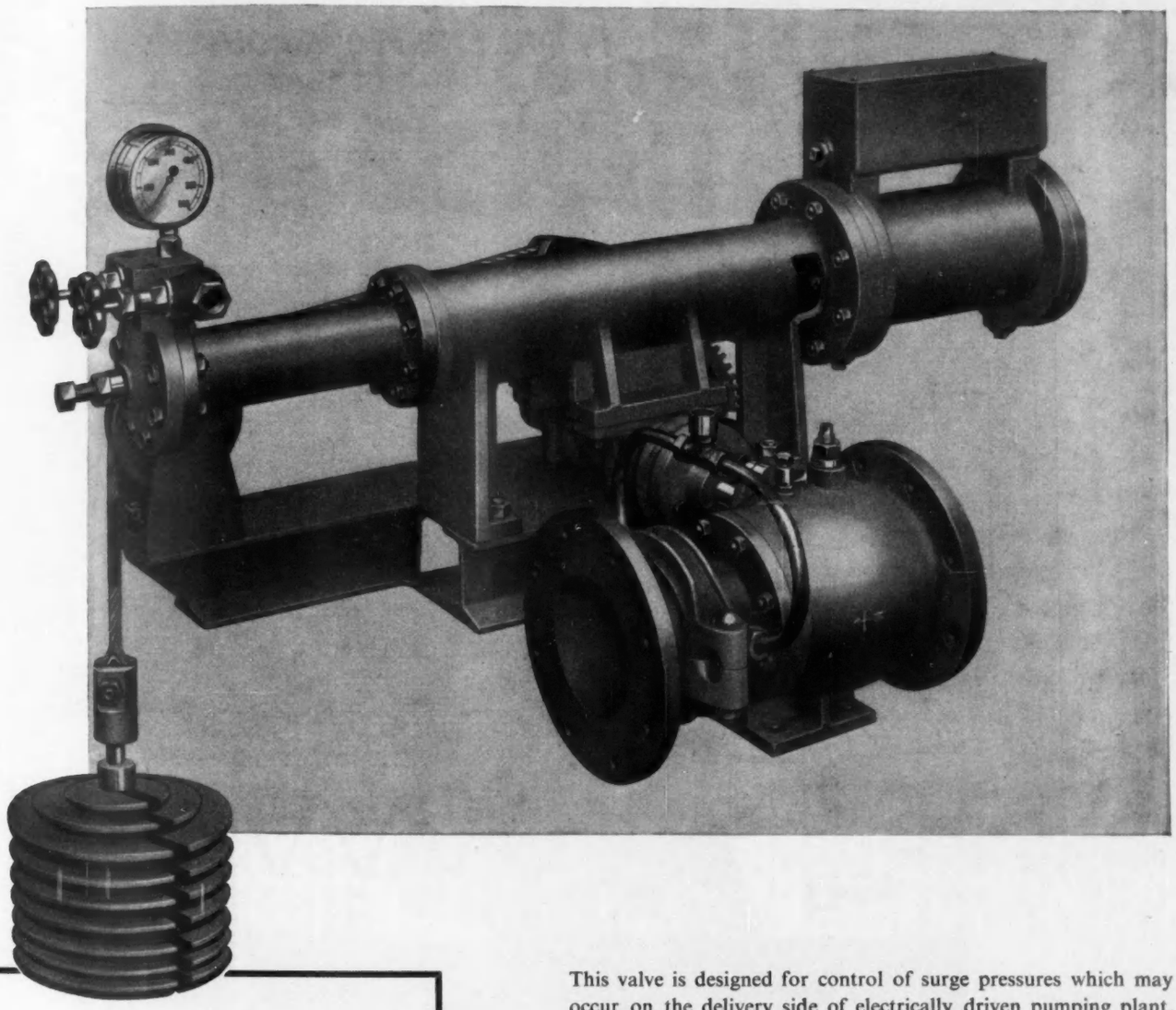
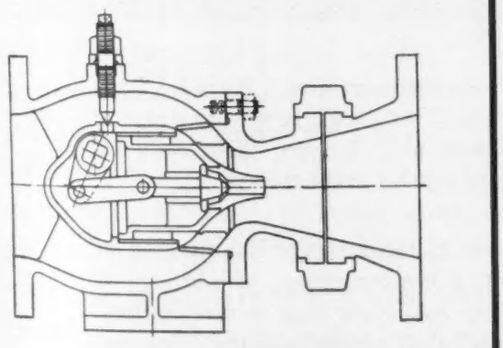
Surge Suppressor





SECTION THROUGH VALVE

This valve is designed for control of surge pressures which may occur on the delivery side of electrically driven pumping plant, following sudden stopping of the pump, or involuntary shut-down due to power failure. Installed on a branch from the delivery main, it opens automatically during the period of sub-normal which precedes the high pressure wave, preventing development of the latter by allowing water to discharge to waste (or the suction well). On re-establishment of normal pressure, closure takes place again automatically. The valve is of Larner-Johnson Balanced Streamline type for efficient handling of the high velocity discharge, and both opening and closing operations are controlled and adjustable.

This type is effective on installations with long rising mains, where the low pressure period is of ample duration to allow the suppressor to open. Other designs are available for other conditions, and we shall be glad to make suitable recommendations, given the requisite data.

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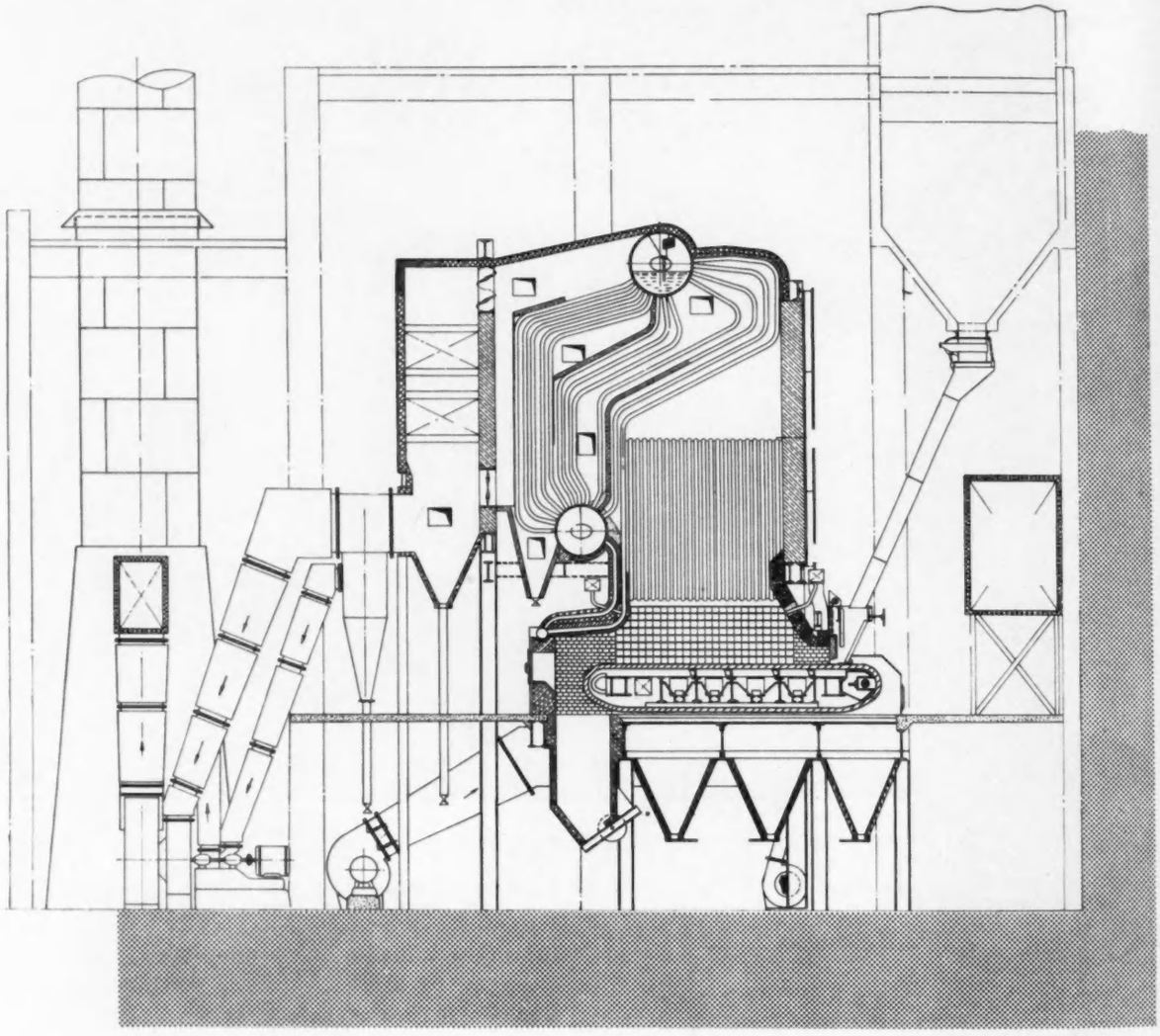
INDUSTRIAL BOILERS

From the New Source



This time it is John Brown Land Boilers for Johannesburg General Hospital. Each of the three steam generators has a capacity of 30,000 lb/hr. supplying steam at 200 lb/sq. in. Equipped with Brown Riley Mechanical Stokers, these units are complete with superheaters, economisers, deaeraters and evaporators.

At Whitecrook Works, Clydebank, we build industrial boilers ranging in capacity from 14,000 lb/hr. to 150,000 lb/hr. Complete ranges of Mechanical Stoker or pulverised fuel firing equipment and all auxiliaries such as economisers, airheaters and mechanical draught plants are supplied to suit individual requirements.

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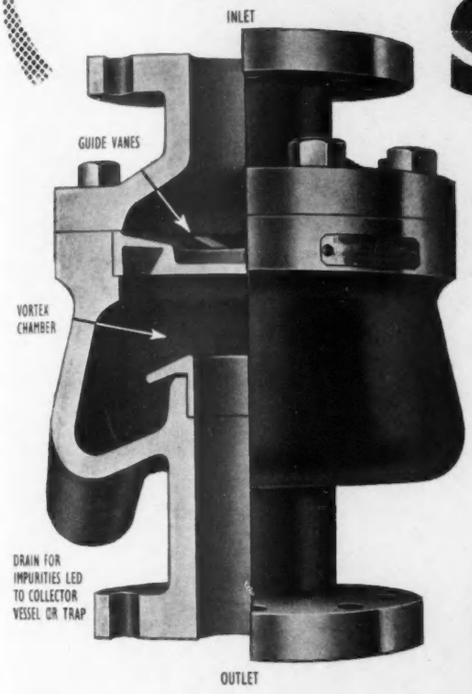
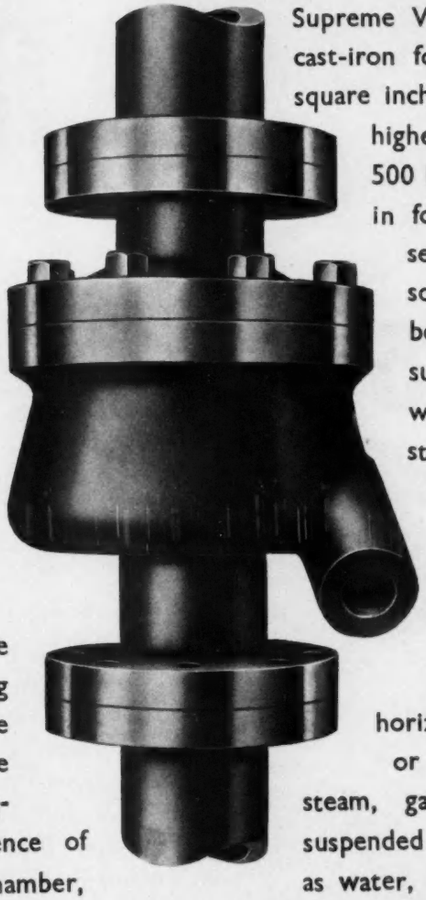
WHITECROOK CLYDEBANK GLASGOW

SUPREME VORTEX SEPARATORS

ALEXANDER'S PATENT

for the purification of Steam, Air or Gas





Supreme Vortex separators are supplied in cast-iron for pressures up to 150 lbs. per square inch and in cast-steel or gunmetal for higher pressures. For pressures above 500 lbs. per square inch special designs in forged steel can be supplied, the separator parts being machined from solid forgings. The shape of the body of the separator is admirably suited to withstand high pressures without employing objectionable strengthening webs which localise stresses and make stress values uncertain.

The extraction of impurities at all rates of flow is over 99% of any liquid or solid particles down to 1/250 inch diameter and a high percentage of even finer particles, providing the liquid solid content at entry does NOT exceed 15%. The separators are entirely self clearing even when the solid portion of the impurities is as much as 20% of the liquid portion. Because of the streamline flow and the complete absence of obstructions in the separating chamber, the pressure drop in vortex separators is at a minimum as compared with other separators of equal bulk and dealing with equal flow.

The separators can be fitted in all pressure pipes arranged for horizontal flow or downward vertical or inclined flow and conveying steam, gas or air in which there are suspended liquid or solid impurities such as water, oil, grit or scale. They are also useful for refrigeration, in the separation of the liquid phase from the gaseous phase of the working fluid used.

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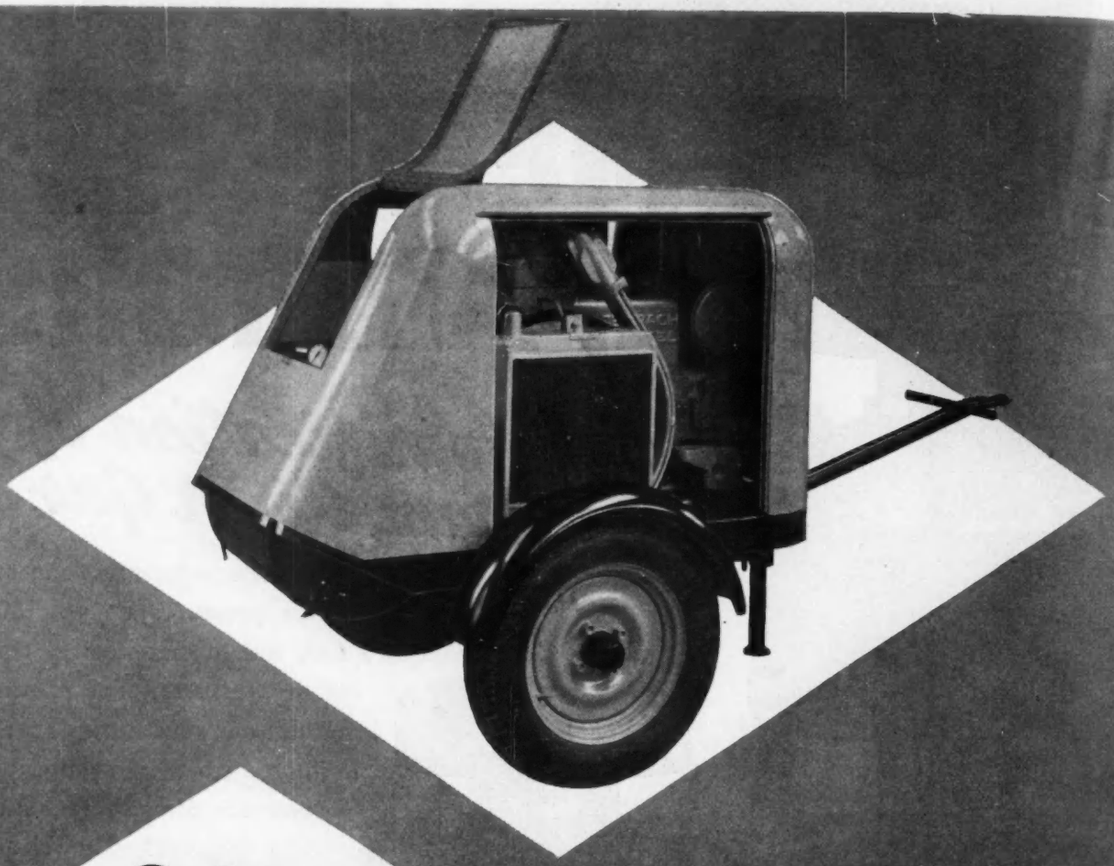
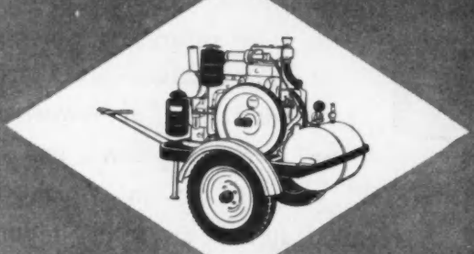
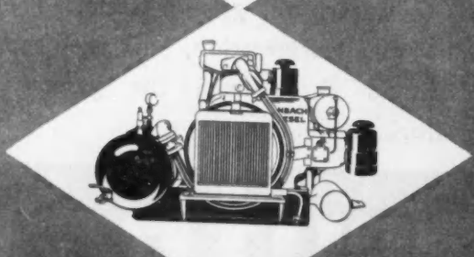


£475 BUYS THE JENBACH

THE BIGGEST DIESEL COMPRESSOR BARGAIN IN BRITAIN TODAY!





The JENBACH Diesel Compressor, model JW20K, widely used throughout the world under all climatic conditions, is not only the newest thing in compressors to reach this country, it is *unapproachably lower in price than any other compressor obtainable in Britain.* A mobile unit with a capacity of 78 cu. ft. at a pressure of 100 lb./sq. in. its special type of transmission ensures greater equilibrium and a remarkable degree of freedom from vibration. The JENBACH offers users maximum performance at the least cost. Comprehensive after sales service. Fully illustrated literature on request to sole distributors in England and Wales.

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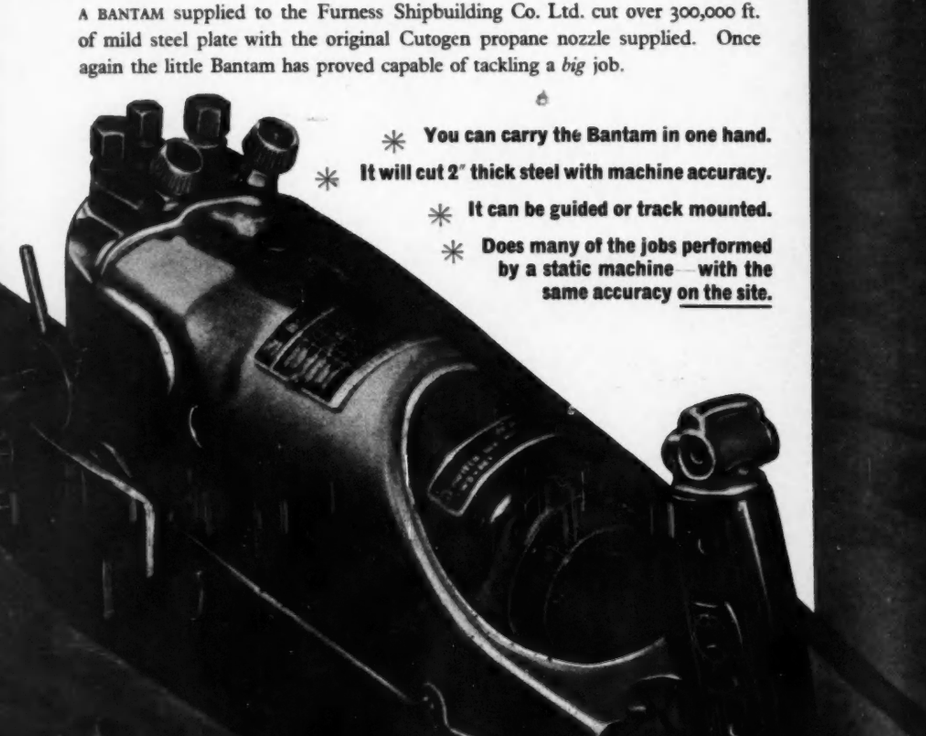
Bantam CUTS OVER 57 MILES OF STEEL —WITH ONE NOZZLE

A BANTAM supplied to the Furness Shipbuilding Co. Ltd. cut over 300,000 ft. of mild steel plate with the original Cutogen propane nozzle supplied. Once again the little Bantam has proved capable of tackling a *big* job.



- You can carry the Bantam in one hand.
- It will cut 2" thick steel with machine accuracy.
- It can be guided or track mounted.
- Does many of the jobs performed by a static machine—with the same accuracy on the site.

BRITISH OXYGEN

British Oxygen Gases Limited, Industrial Division, Bridgewater House, St. James's, London, S.W.1

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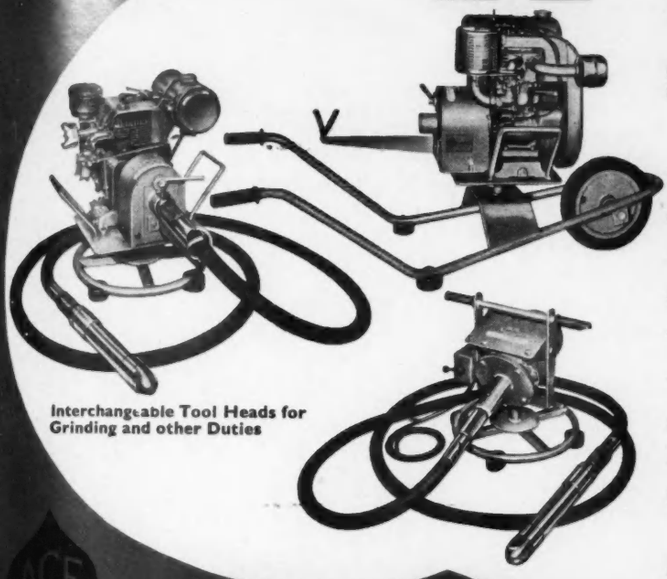

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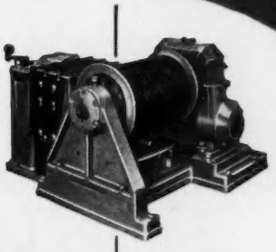
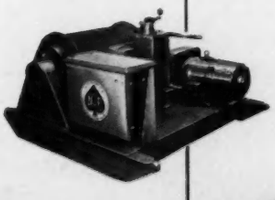
FOR HAULING, HOISTING, ERECTING AND CONSTRUCTION DUTIES





Standard and special types for steel erecting, skip hoists, transporters, wharf cranes, general haulage and building construction. Capacities from half ton (500 kilos) upwards. Send for full particulars.

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We offer the only complete advisory service

on flexible tubing and hose. As suppliers of all types and in all materials, we can recommend 'flexibles' best suited to a particular job, *and at the right price.*

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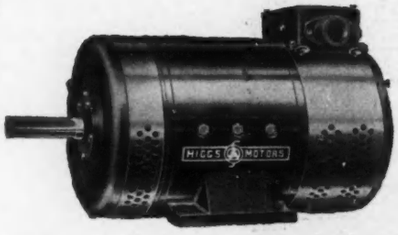

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Today, as 100 years ago, craftsmanship in the E S C foundry is of the highest order. This tradition, coupled with vast experience and the most complete plant of any Steel Foundry in the British Commonwealth, guarantees a sound and satisfactory product.

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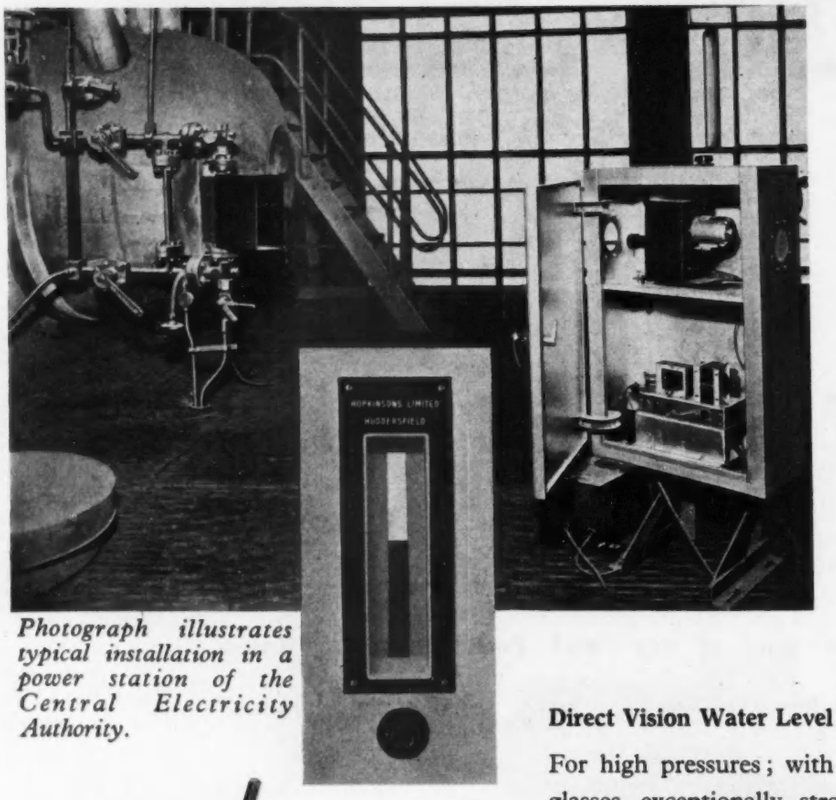
The latest in
WATER LEVEL INDICATORS

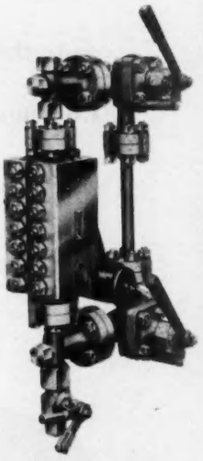


Photograph illustrates typical installation in a power station of the Central Electricity Authority.

We have standardised the four systems of Water Level Indication illustrated on this page.

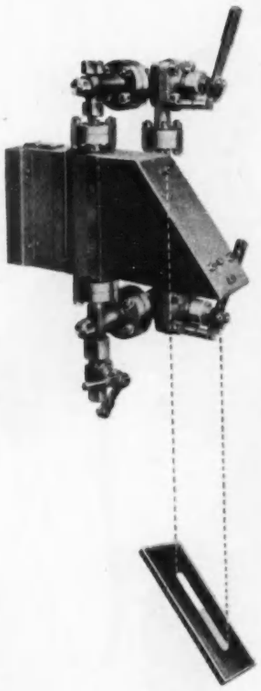
Remote indication by television system

An innovation comprises remote indication by means of a viewing camera which transmits electrically to a cathode-ray tube situated at any convenient location at the firing floor, giving a continuous accurate indication of the water level.



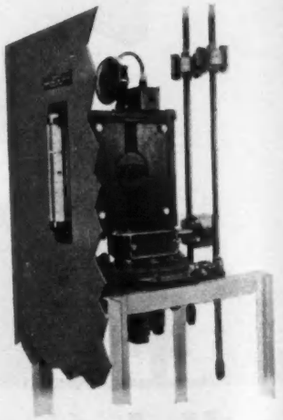
Direct Vision Water Level Indicator

For high pressures; with double plate glasses, exceptionally strong, giving a clear visual demarcation between steam and water. For shell type boilers we make a full range of direct-vision Bronze Water Gauges.



Direct Bi-colour Water Level Indicator

Gives a brilliant reflected image at eye level at the firing floor, showing sharply contrasted colours, red for steam and blue for water.



Remote Bi-colour Water Level Indicator

Gives brilliant contrasting illuminated colours (red and blue) at full scale at the firing floor; can be combined with audible warning, continuous recorder and distant repeater if required.

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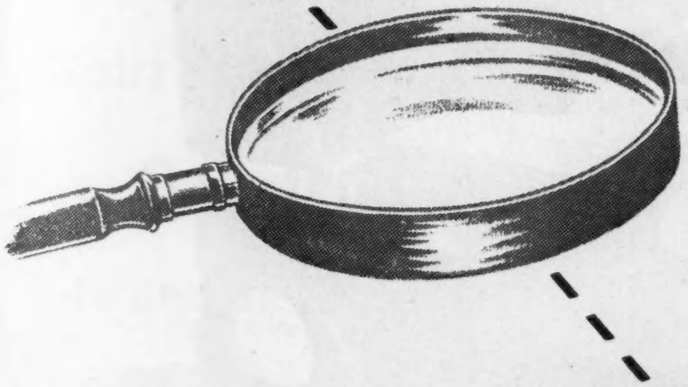
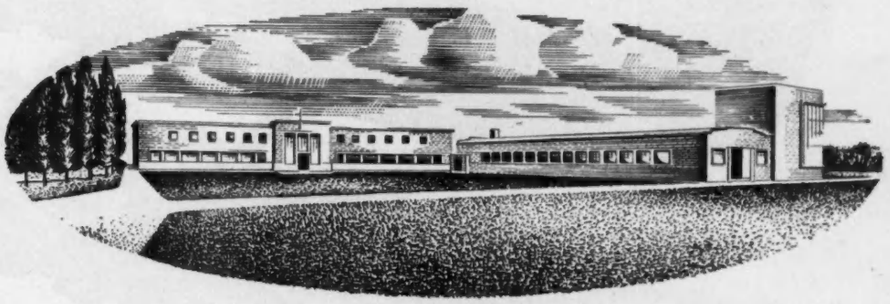
HV 81

An "inside" job . . .

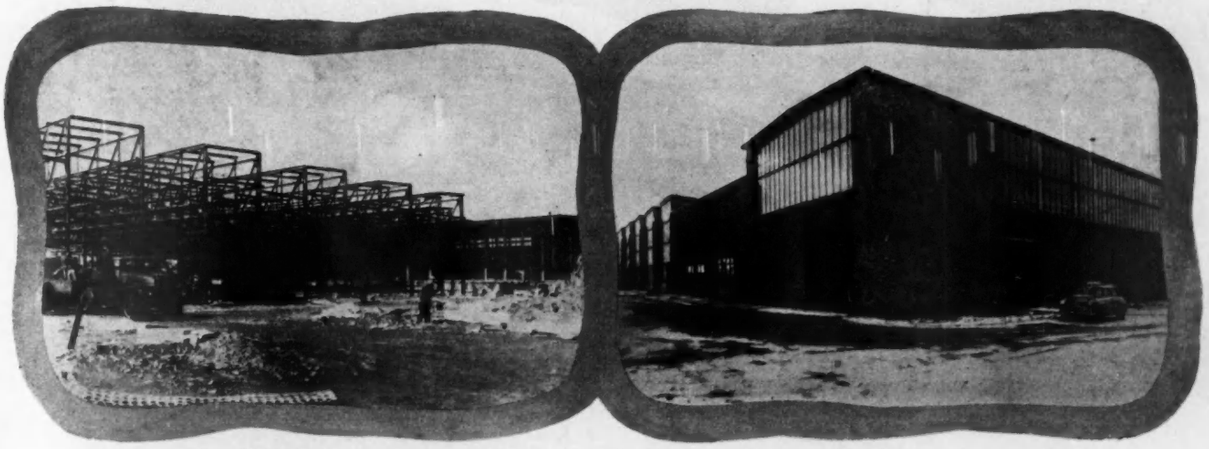


The asscciated companies of the Owen Organisation with so many resources at their command, often help each other in service to the customer and particularly in combining forces in the field of research and development. So it is with this " inside job ".

New design and research laboratories for Electro Hydraulics Limited and a new assembly bay for conveyancer Fork Trucks Limited, incorporate steelwork designed, fabricated and erected by Rubery Owen.



Electro Hydraulics, Ltd., Warrington.
New design and research laboratories, erected with a view to furthering under-carriage design and research, contain 165 tons of steelwork.



Conveyancer Fork Trucks, Limited, Warrington.
New Assembly bay for production of Fork Trucks, contains 430 tons of steelwork.

RUBERY OWEN & COMPANY LTD.

STRUCTURAL DIVISION, P.O. Box 10, Darlaston, Wednesbury, Staffs. Phone: James Bridge, 3131

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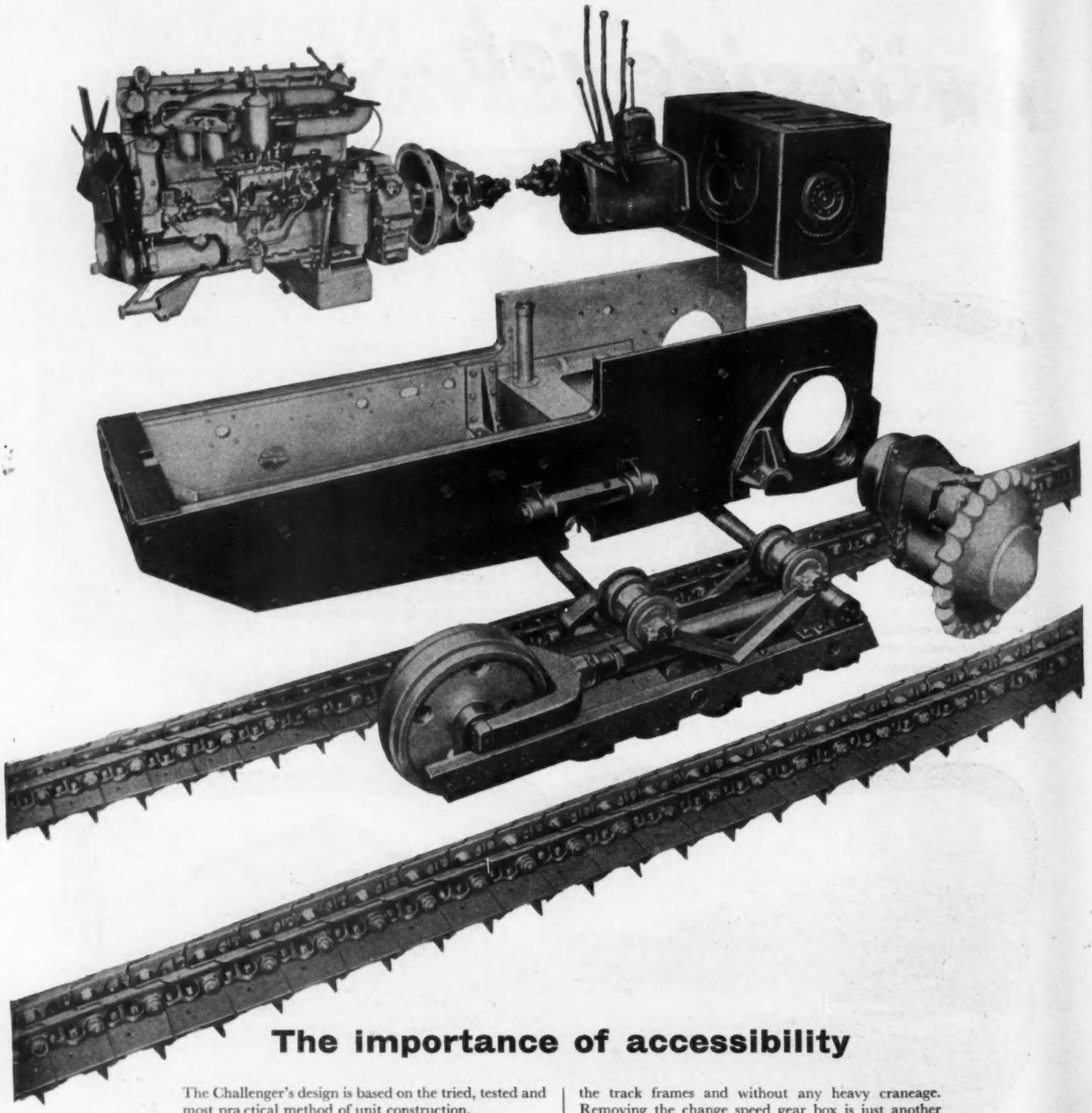

The importance of accessibility

The Challenger's design is based on the tried, tested and most pra ctical method of unit construction.
Unit construction makes it remarkably easy to service the Challenger. It mean s that all essential parts are easily accessible to the maintenance mechanic. Suppose the final drive needs attention. The whole job can be done without ja cking up the tractor, without removing any of the transmission units, without interfering with the track frames and without any heavy craneage. Removing the change speed gear box is just another quick job—you simply disconnect the propeller shaft, unbolt the gear box from the bevel box, and there you are. Thus the design and unit construction of the Challenger means less time in the workshop and more time on the job. It is popular alike with maintenance staff and with operators.

More earth moved faster by Challenger

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Send your enquiry for castings in S.G. Iron to one of these licensed producers

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Use electricity and bring the heat to the job instead of having to bring the job to the heat. Heat can be applied wherever it is possible to bring a pair of wires—and so the heating process can be right in the line of production.

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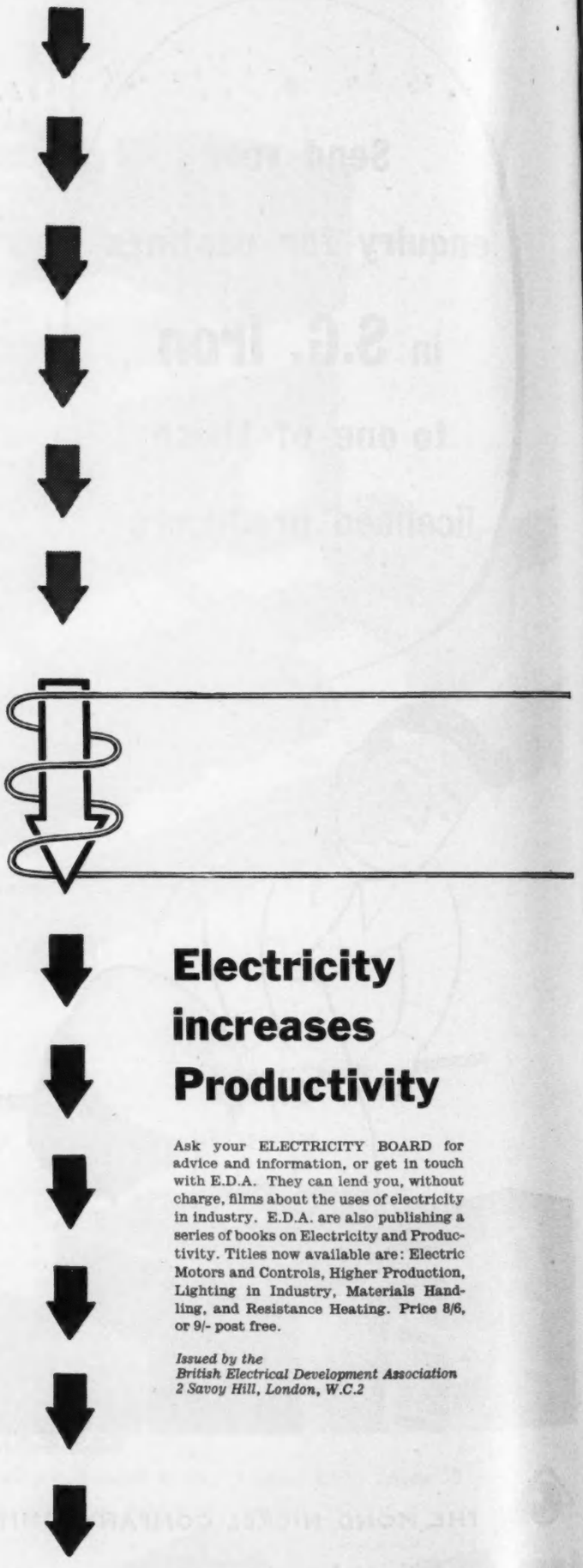
Heat where you want it, perfect control, cleanliness, lower labour costs and better working conditions are some of the advantages of using electricity for heating. *Heating is just one of the many ways in which electricity plays a vital part in the drive for greater productivity.*



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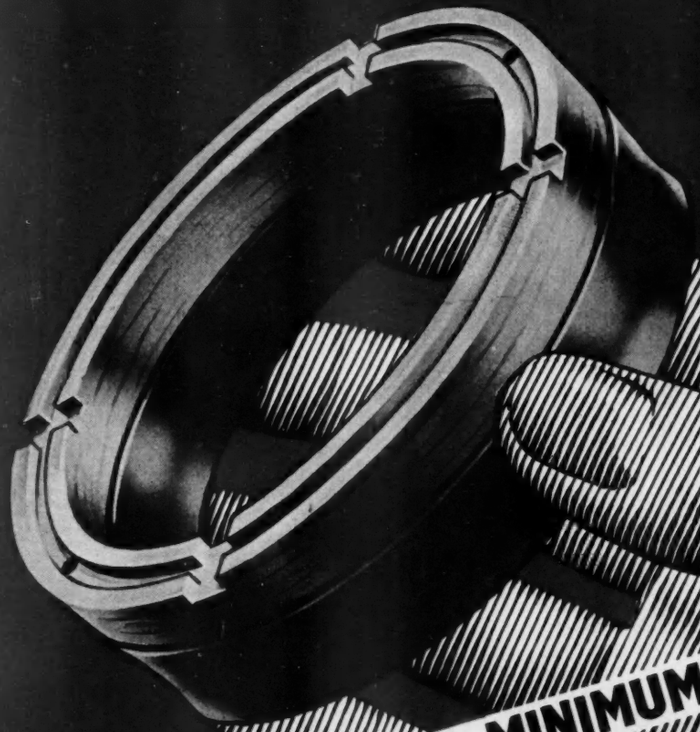
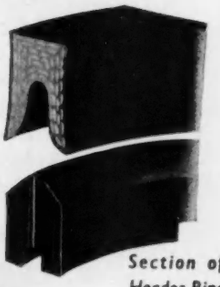


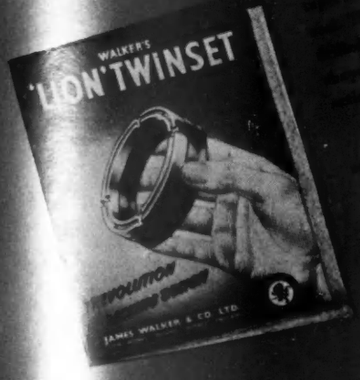
SEALING PERFECTION WITH MINIMUM OF FRICTION

Section of 'U' Ring showing tapered lips



Section of Header Ring

WALKER'S LION PACKING



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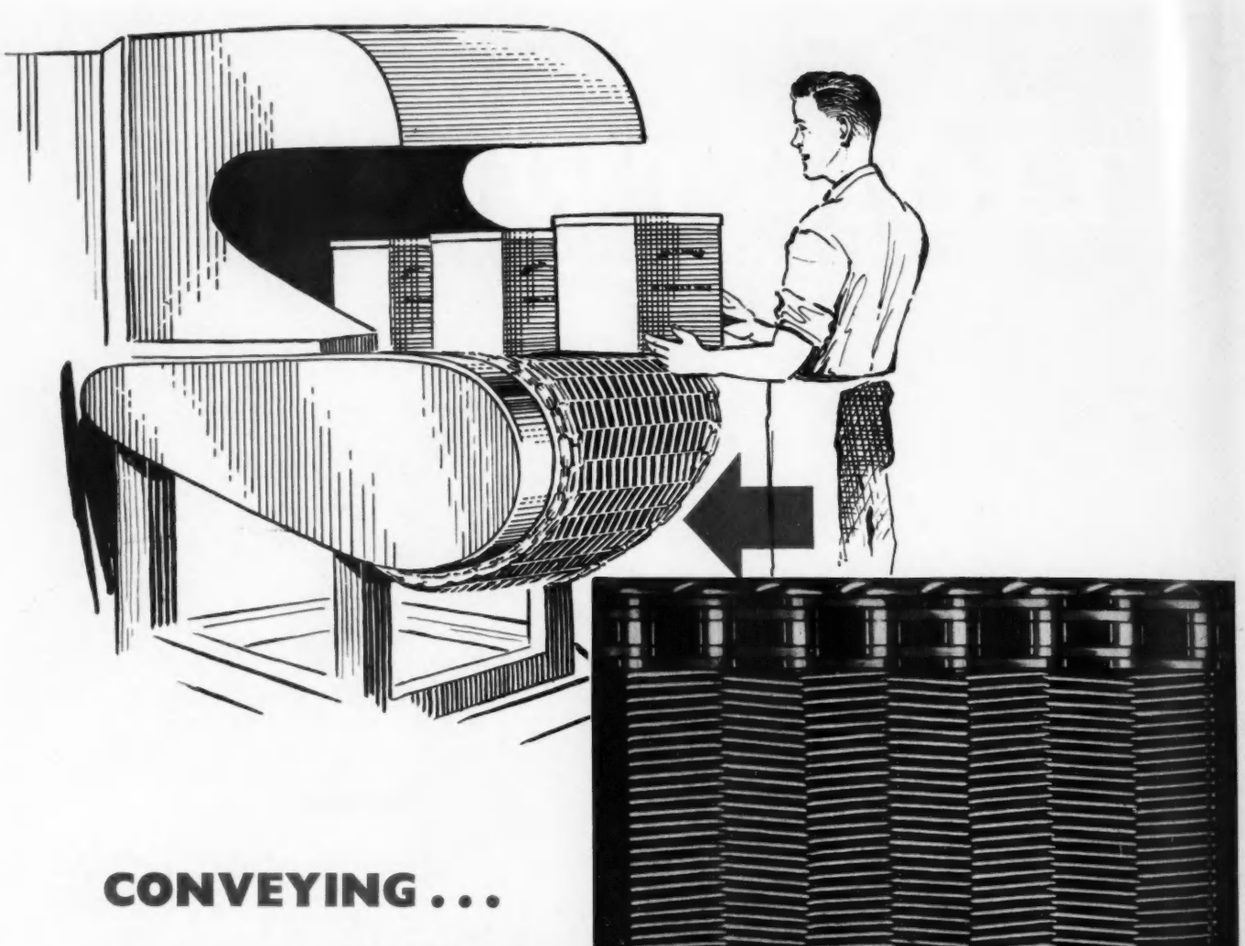

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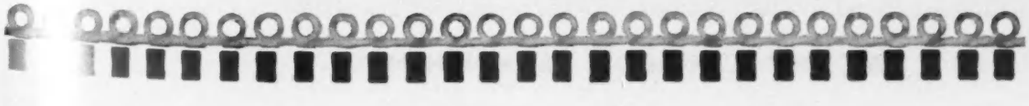

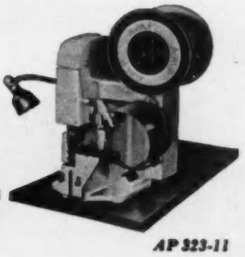

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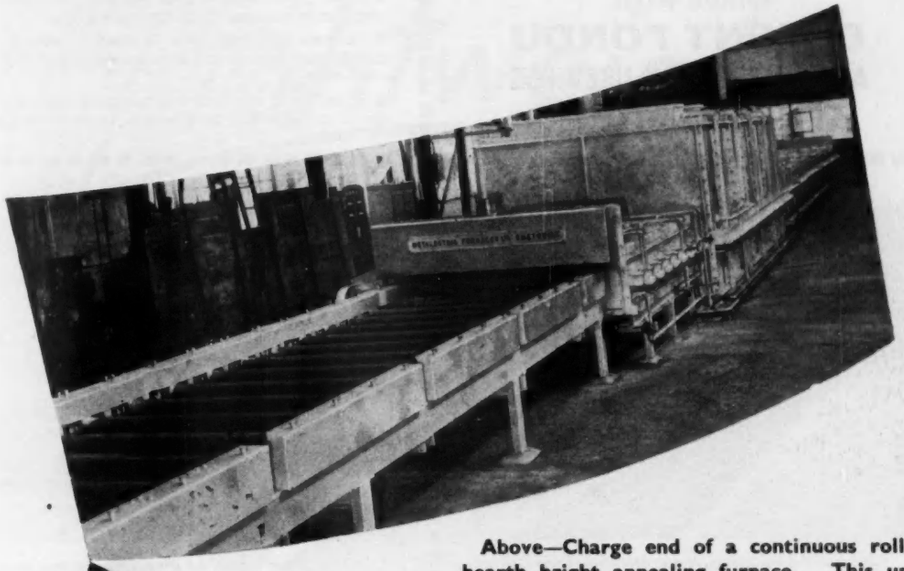
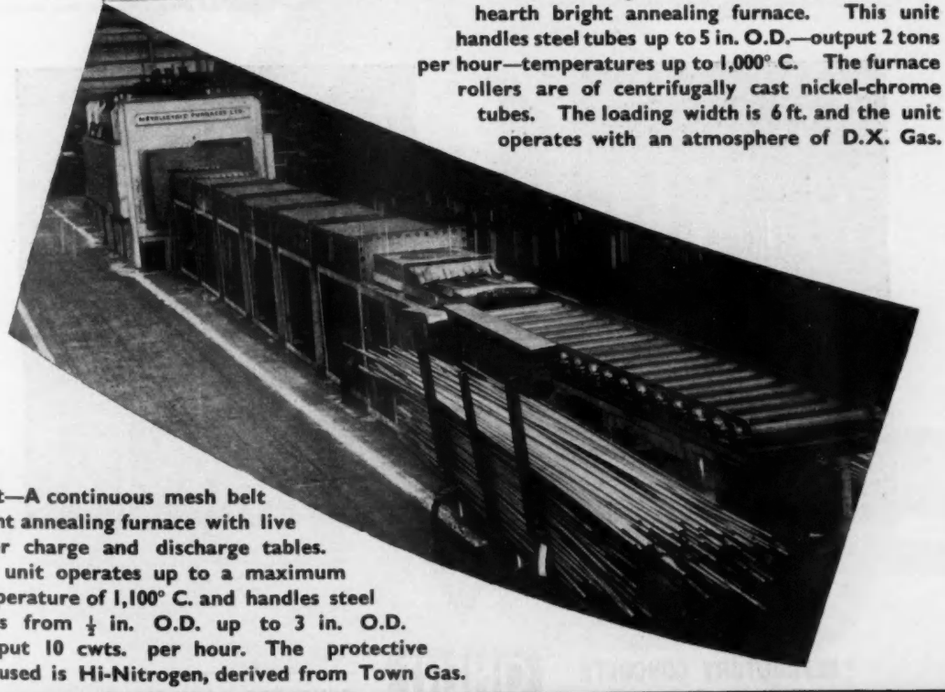


Above—Charge end of a continuous roller hearth bright annealing furnace. This unit handles steel tubes up to 5 in. O.D.—output 2 tons per hour—temperatures up to 1,000° C. The furnace rollers are of centrifugally cast nickel-chrome tubes. The loading width is 6 ft. and the unit operates with an atmosphere of D.X. Gas.



Right—A continuous mesh belt bright annealing furnace with live roller charge and discharge tables. The unit operates up to a maximum temperature of 1,100° C. and handles steel tubes from ½ in. O.D. up to 3 in. O.D. Output 10 cwts. per hour. The protective gas used is Hi-Nitrogen, derived from Town Gas.

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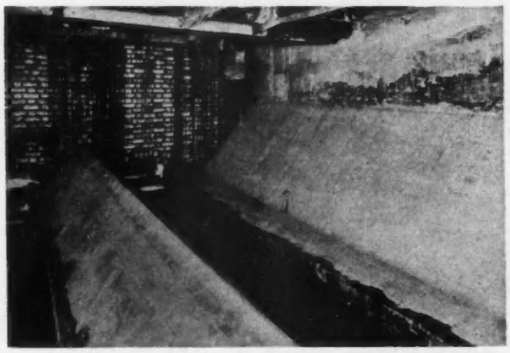
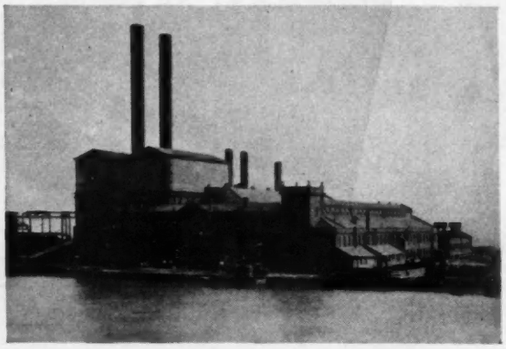
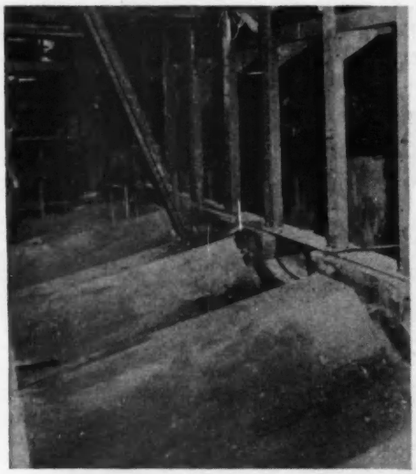


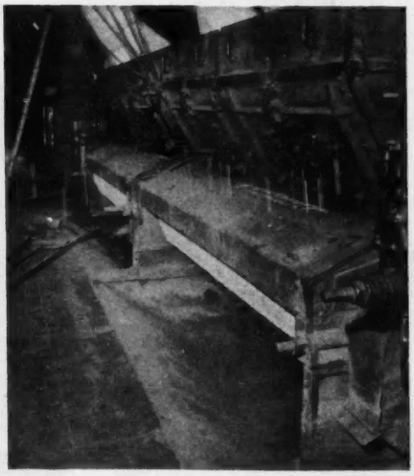
Clarence Dock Power Station. Hopper lined with ordinary Ciment Fondu concrete and the brickwork pointed with Ciment Fondu mortar.



Brighton 'A' Power Station. Ash pits and chimneys lined with ordinary Ciment Fondu concrete.



*Battersea Power Station. Ash Hopper Foundation of *Refractory Concrete designed to catch the hot burnt out ash falling from the boiler grate and wash it into the ash race. Overall size is 34' by 15' 6" by 4' 2".*



Acton Power Station. Hopper beneath chain grate stoker lined with ordinary Ciment Fondu concrete. Linings are 12' long by 2" and extend the full width of the grate.

***REFRACTORY CONCRETE the adaptable Refractory material made with crushed firebrick and CIMENT FONDU**

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CONCRETE ROCK-HARD WITHIN ONE DAY

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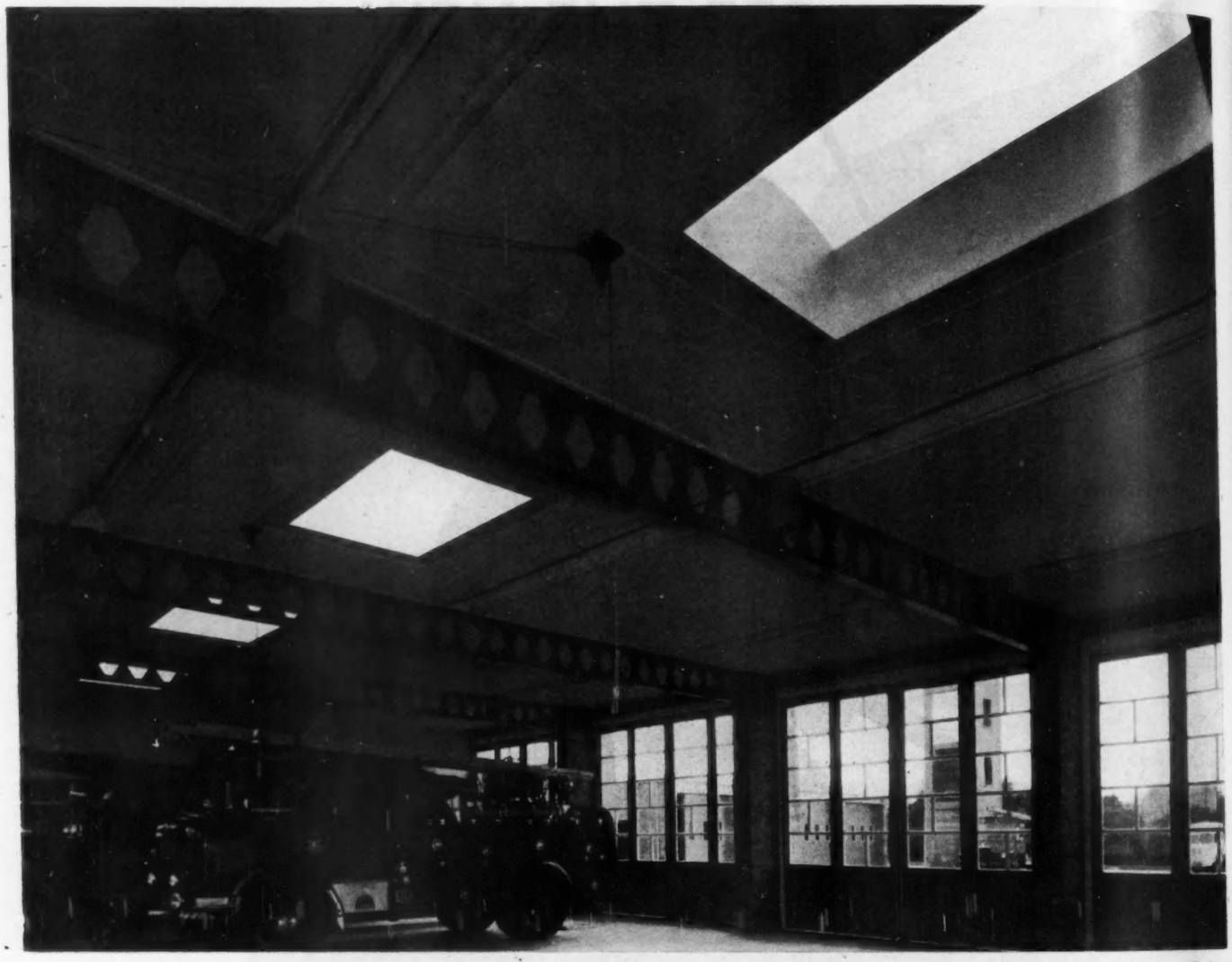
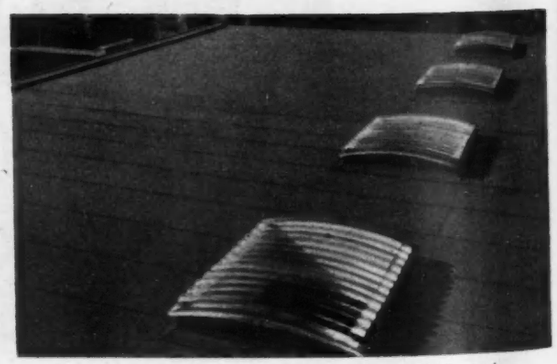


Interior of Lindsey County Council Fire Brigade and Ambulance Station at Gainsborough, Lincs. Roof windows are in Corrugated 'Perspex'.

Modern Fire Station fitted with Corrugated 'PERSPEX' roof lights

CORRUGATED 'PERSPEX' is unequalled as a roofing material in all buildings where toughness, durability and high light transmission are important. Corrugated 'Perspex' will stand up to any amount of external weathering, as well as extreme heat or cold. It represents a considerable saving over conventional materials.

Corrugated 'Perspex' is very light, easy to handle, and not expensive to install. For those rare instances in this country where diffused daylight may be more desirable, Opal 'Perspex' is available. Originally developed for intense light conditions overseas, Opal Corrugated 'Perspex' diffuses daylight efficiently.



View of the roof from above. Corrugated 'Perspex' transmits a very high proportion of daylight.

It's as clear as daylight—it must be Corrugated 'PERSPEX'

'Perspex' is the registered trade mark for the acrylic sheet manufactured by I.C.I.

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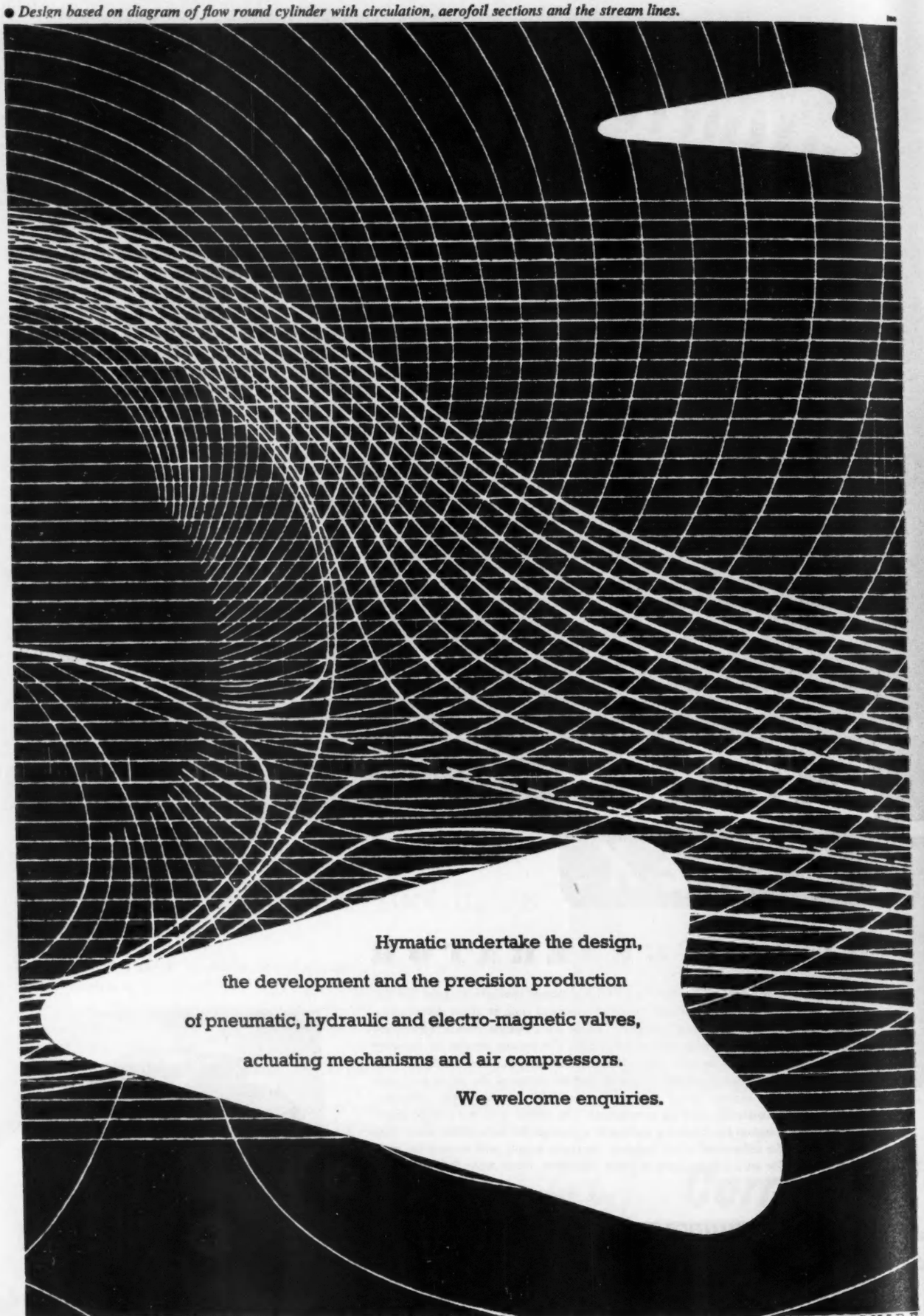
The Murex "Dynex" Motor Generator is a new equipment specially designed for d.c. metal arc welding and is also suitable for other processes such as argon arc welding. It incorporates the Murex "Dynex" Generator which gives infinite current adjustment throughout the entire range irrespective of the voltage. The voltage can also be infinitely adjusted. These facilities provide ideal characteristics for modern electrodes and techniques. A polarity changeover switch is fitted and the design of the set is such that neither internal nor external series resistors are required. An accurately calibrated indicator plate eliminates the need for instruments. The output is from 15 to 300 amps. at 30 volts for continuous hand welding and up to 450 amps. for intermittent work. The motor is suitable for connection to any standard electricity supply and is complete with built-in starter. The set is also available in other capacities. Please write for full details.

MUREX ELECTRIC ARC WELDING EQUIPMENT & ELECTRODES

E20 MUREX WELDING PROCESSES LTD., Waltham Cross, Herts.

● *Design based on diagram of flow round cylinder with circulation, aerofoil sections and the stream lines.*


Hymatic undertake the design,
the development and the precision production
of pneumatic, hydraulic and electro-magnetic valves,
actuating mechanisms and air compressors.
We welcome enquiries.

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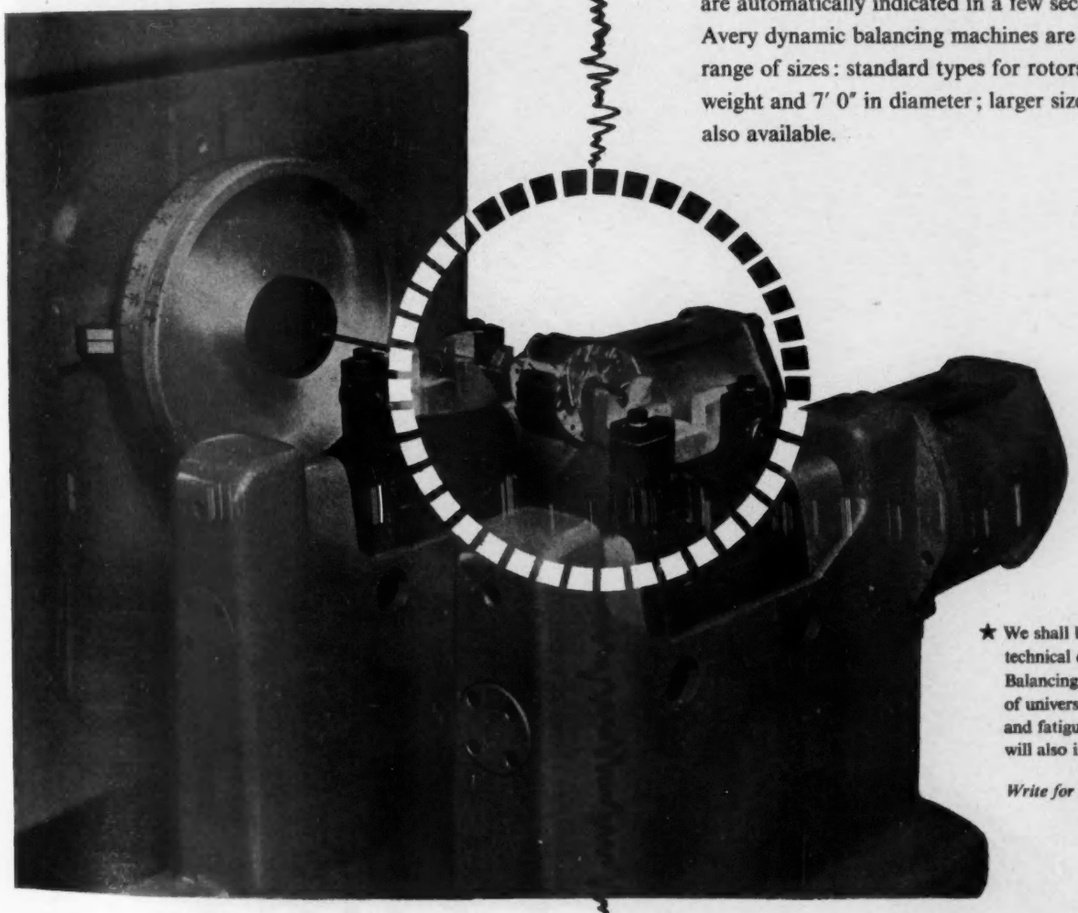
Higher and higher speeds are the order of the day, yet a high-speed rotor must, above all, never reveal its presence by even the slightest tremor. How can you assure that perfect balance is achieved? The answer is *precision dynamic balancing* – an essential checking operation made very simply by an Avery dynamic balancing machine.
Here is a small rotor under test in the Avery 7206 machine. The amount and angular position of the correction required are automatically indicated in a few seconds!
Avery dynamic balancing machines are made in a wide range of sizes: standard types for rotors up to 8,000 lb. in weight and 7′ 0″ in diameter; larger sizes are also available.



★ We shall be pleased to send technical details of Avery dynamic Balancing machines. Our range of universal, tensile, hardness, impact and fatigue testing machines will also interest you.

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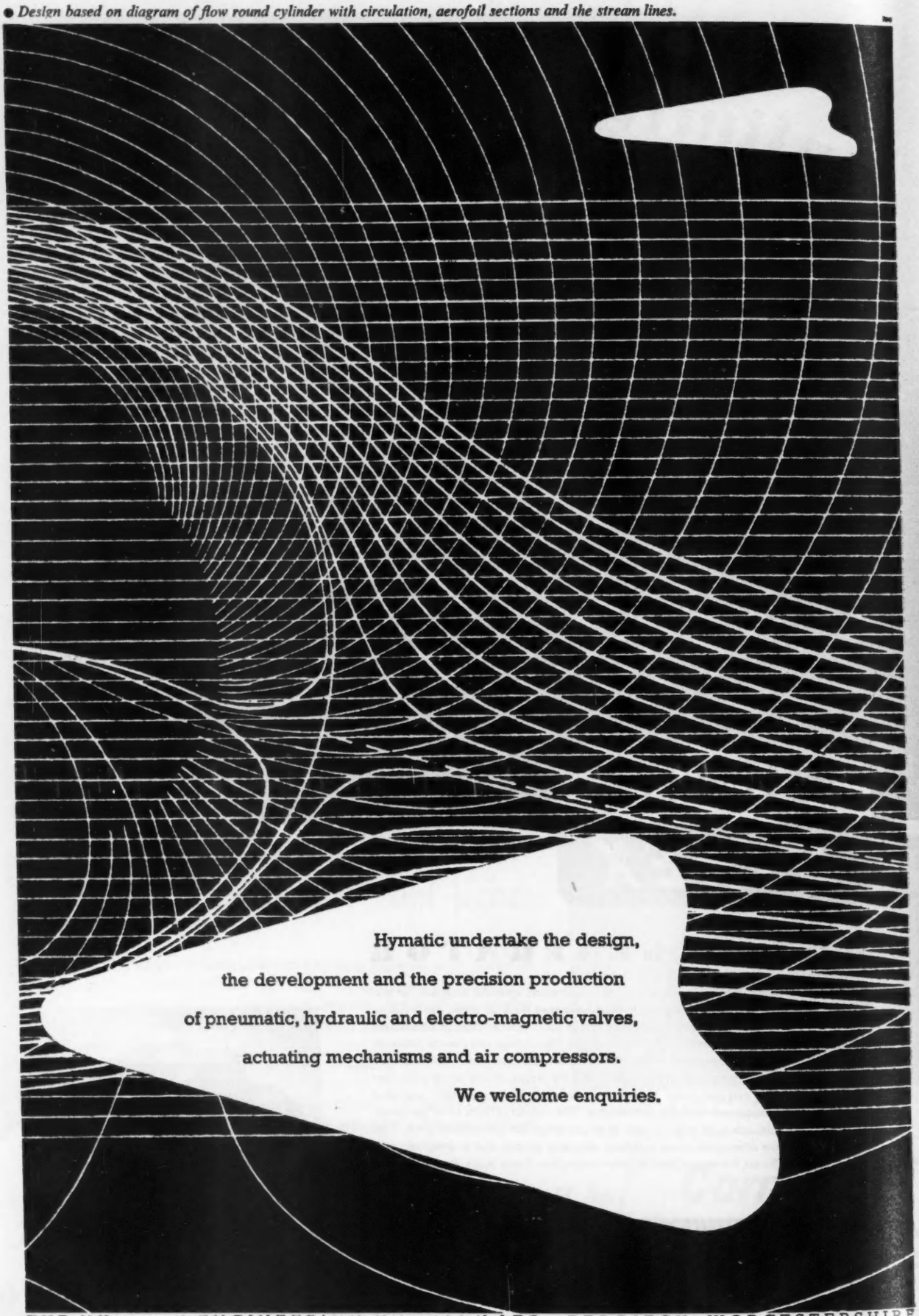
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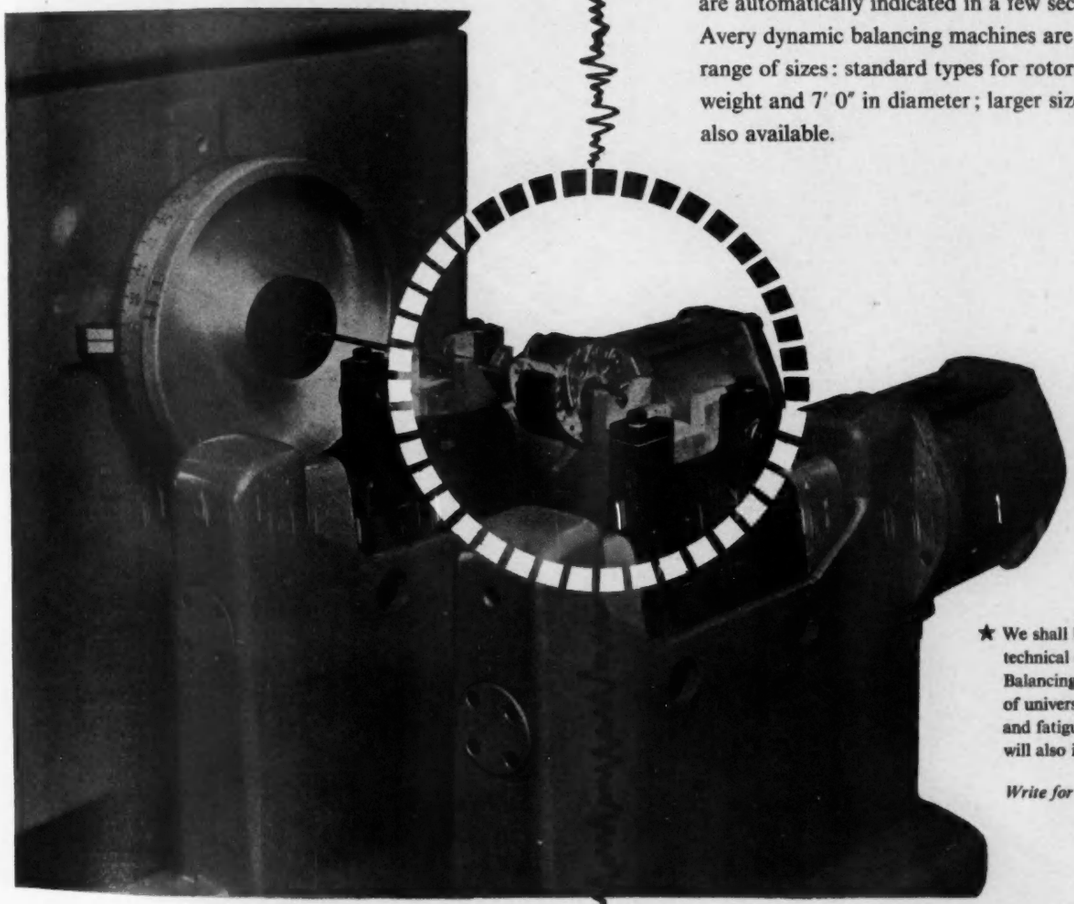

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Photograph by courtesy of Mirrlees, Bickerton & Day Ltd.

The Asquith ' Angular Borer ' shown above was specially designed and built for machining the cylinder bores for Vee-form J. & K. engines in the works of the famous diesel engine builders, Messrs. Mirrlees, Bickerton & Day Ltd.

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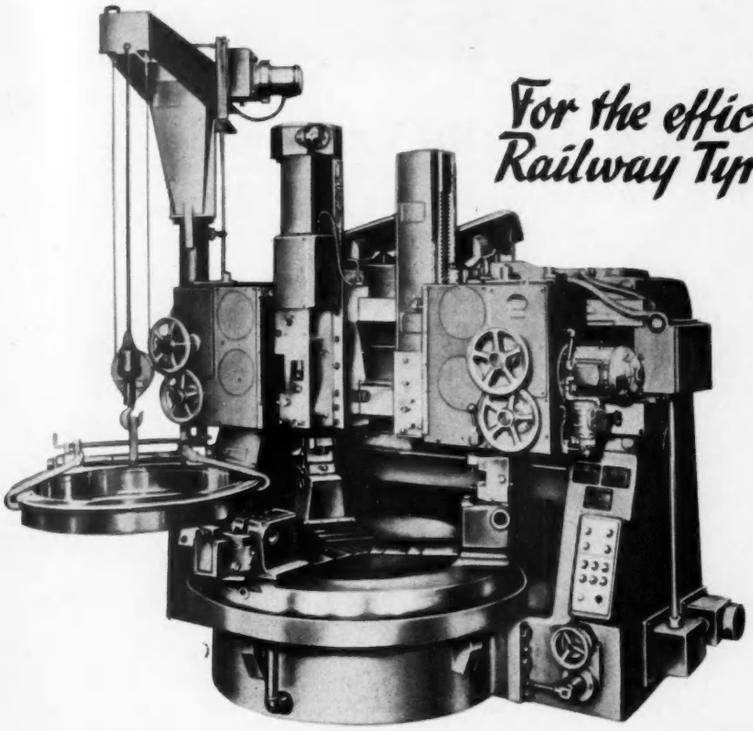

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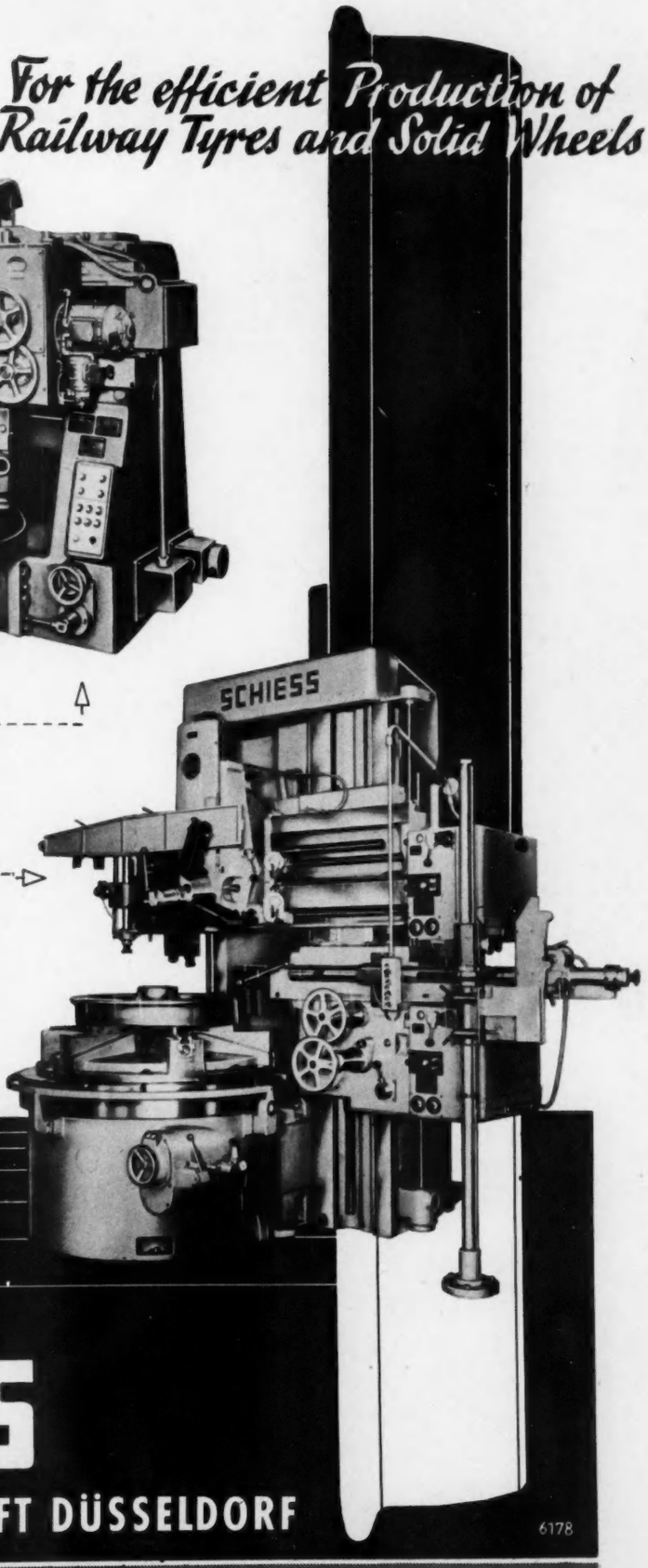

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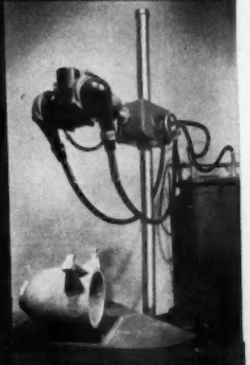

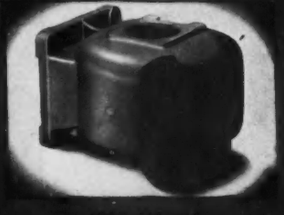

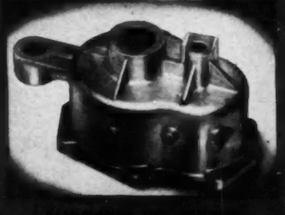

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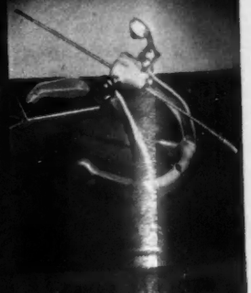

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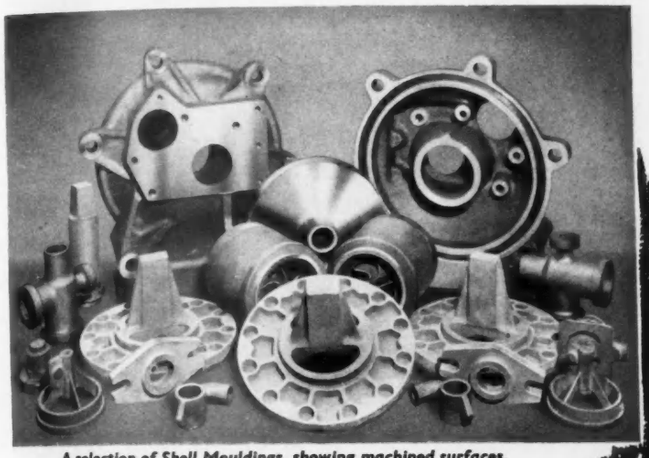

A selection of Shell Mouldings, showing machined surfaces.

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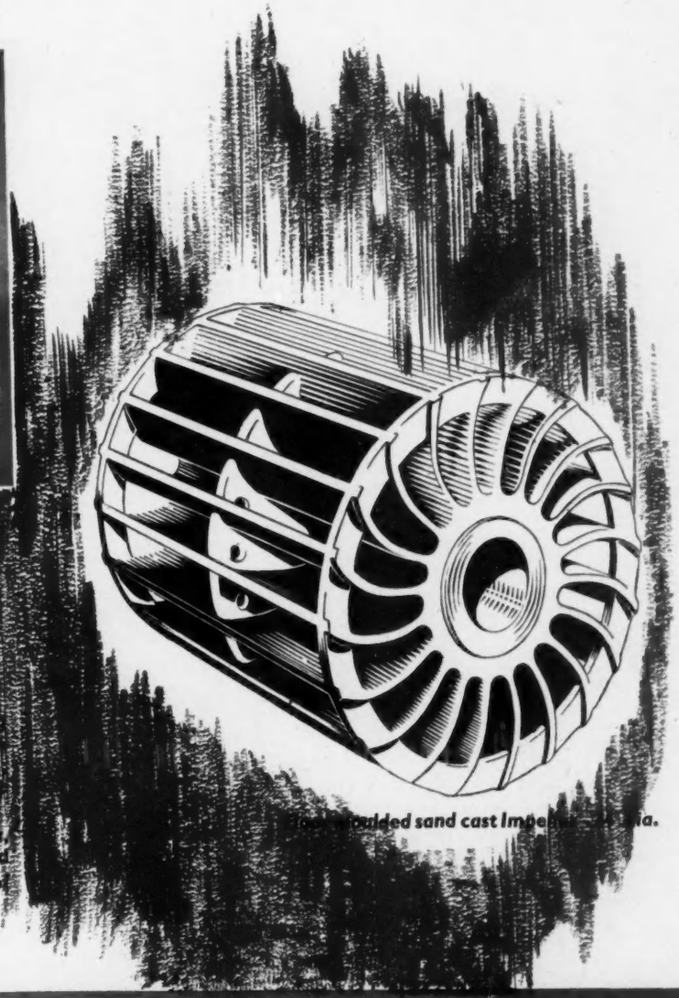
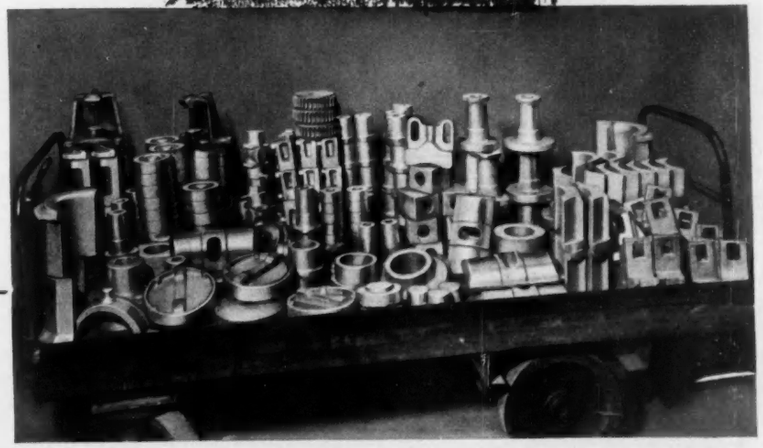


Typical moulded sand cast Impe a.

A selection of typical Bench Mouldings.



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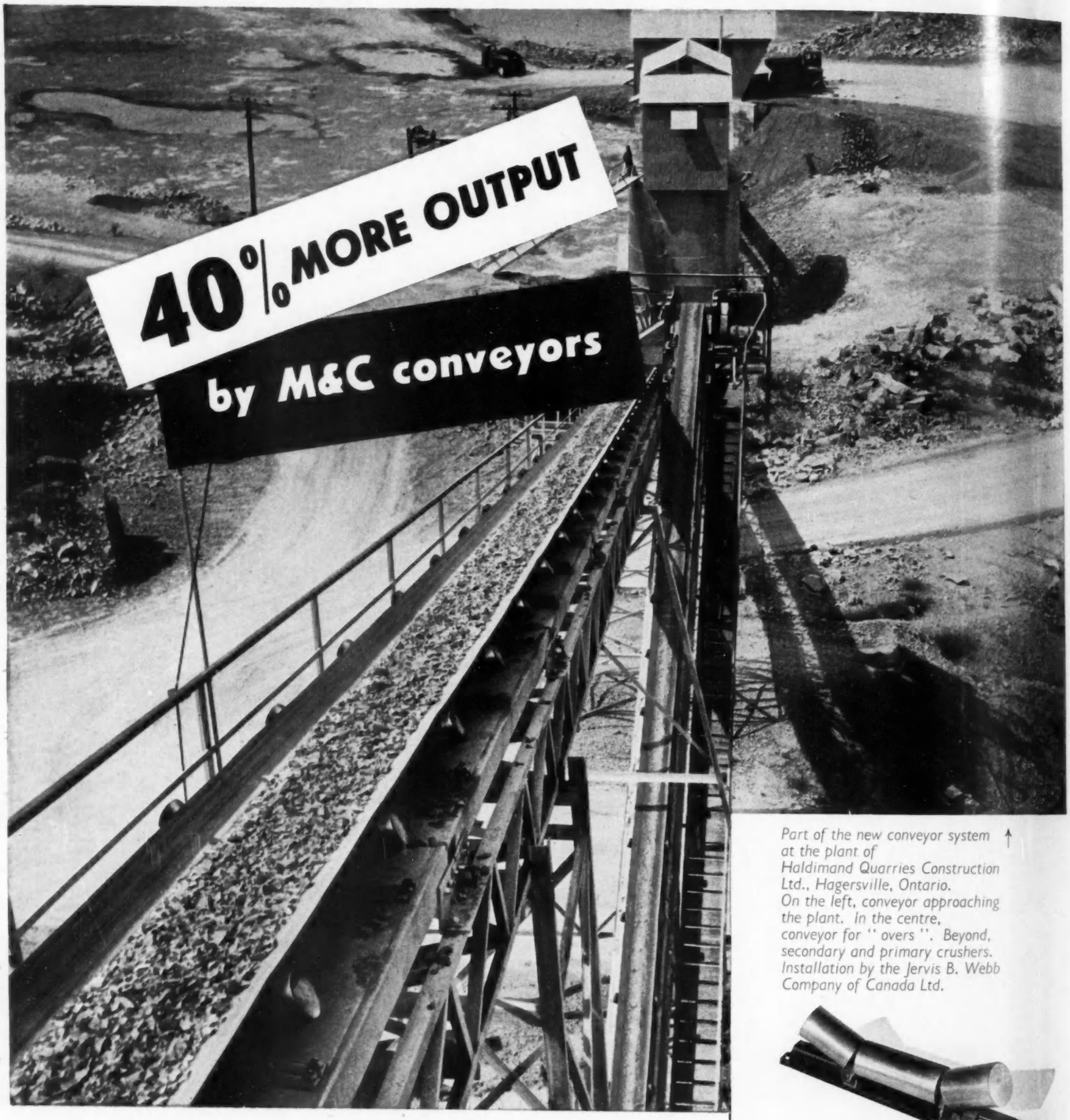

Part of the new conveyor system at the plant of Haldimand Quarries Construction Ltd., Hagersville, Ontario. On the left, conveyor approaching the plant. In the centre, conveyor for "overs". Beyond, secondary and primary crushers. Installation by the Jervis B. Webb Company of Canada Ltd.

"The old plant was always a source of trouble", the Manager writes. "We replaced it with your conveyor system which has done a remarkable job for us with little or no trouble. Our present capacity is about 200 tons per hour of everything passing a 7/8-inch screen opening, an increase of approximately forty per cent."

Increased efficiency is being brought to many belt conveyors by fitting them with M&C idlers, which spin at a touch. Double labyrinth grease seals keep the ball bearings safe and free-running. As a step towards reducing conveying costs, ask for M&C booklets.

Three-pulley idler on corrugated board. M&C idlers are supplied for any type of mounting, and for belts up to 60 in.

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For Belt Conveyors visit M & C on Stand 123, MECHANICAL HANDLING EXHIBITION Earls Court, May 9–19

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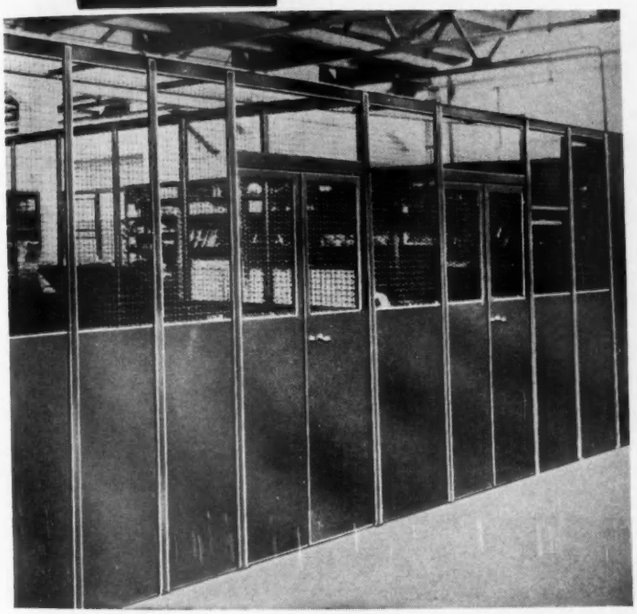

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'Harco' Wirework Partitions

can be tailor-made to suit the space to be enclosed, and supplied as complete sections of any reasonable size, firmly fitted in metal frames for attachment to walls, floor and ceiling. Also available as entirely self-contained enclosures, complete with door and suitable fittings.

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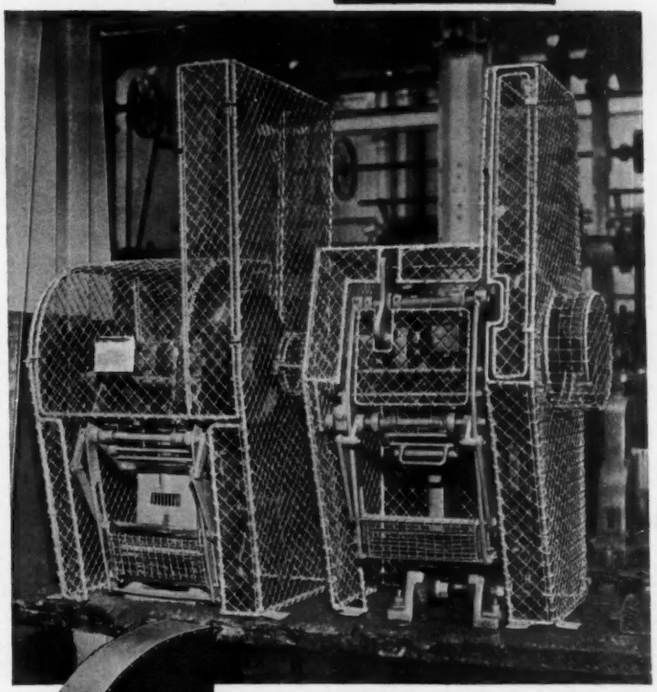

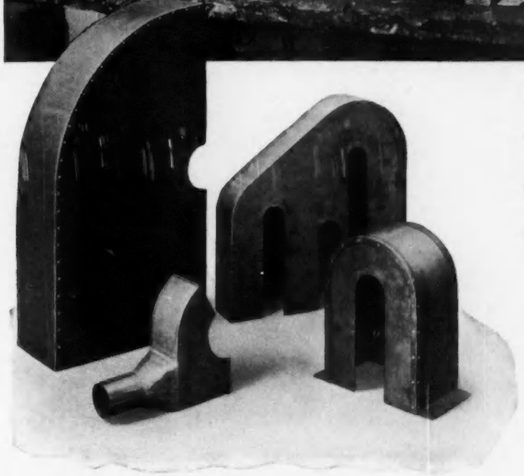

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Production can suffer when skilled men are incapacitated by inadequately protected machinery.

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Send details of requirements or ask for a technical representative to call

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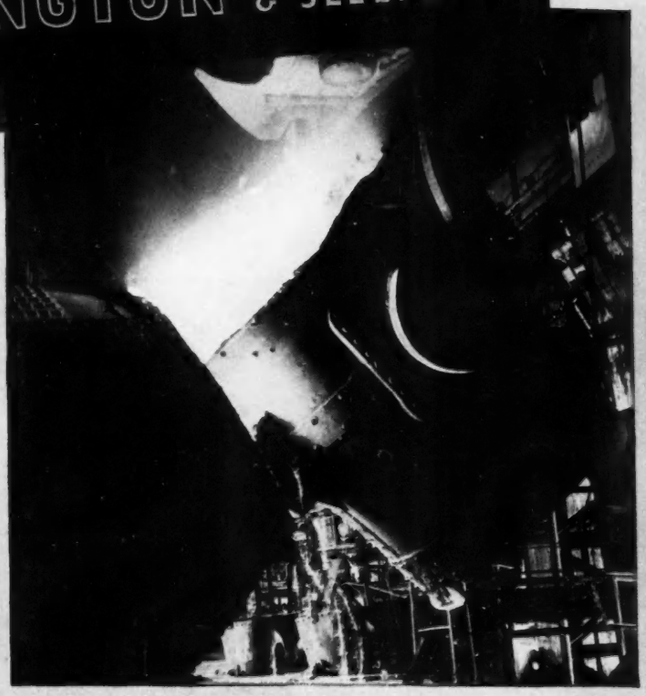

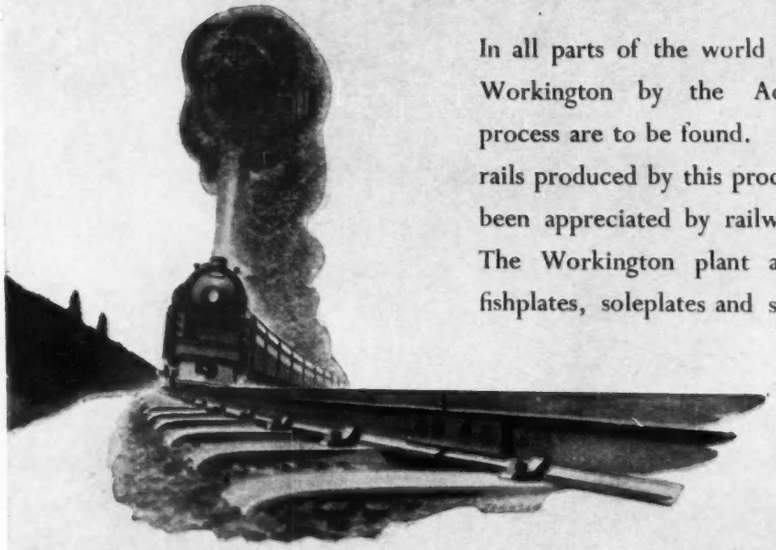

In all parts of the world rails made at Workington by the Acid Bessemer process are to be found. Properties of rails produced by this process have long been appreciated by railway engineers. The Workington plant also produces fishplates, soleplates and steel sleepers.

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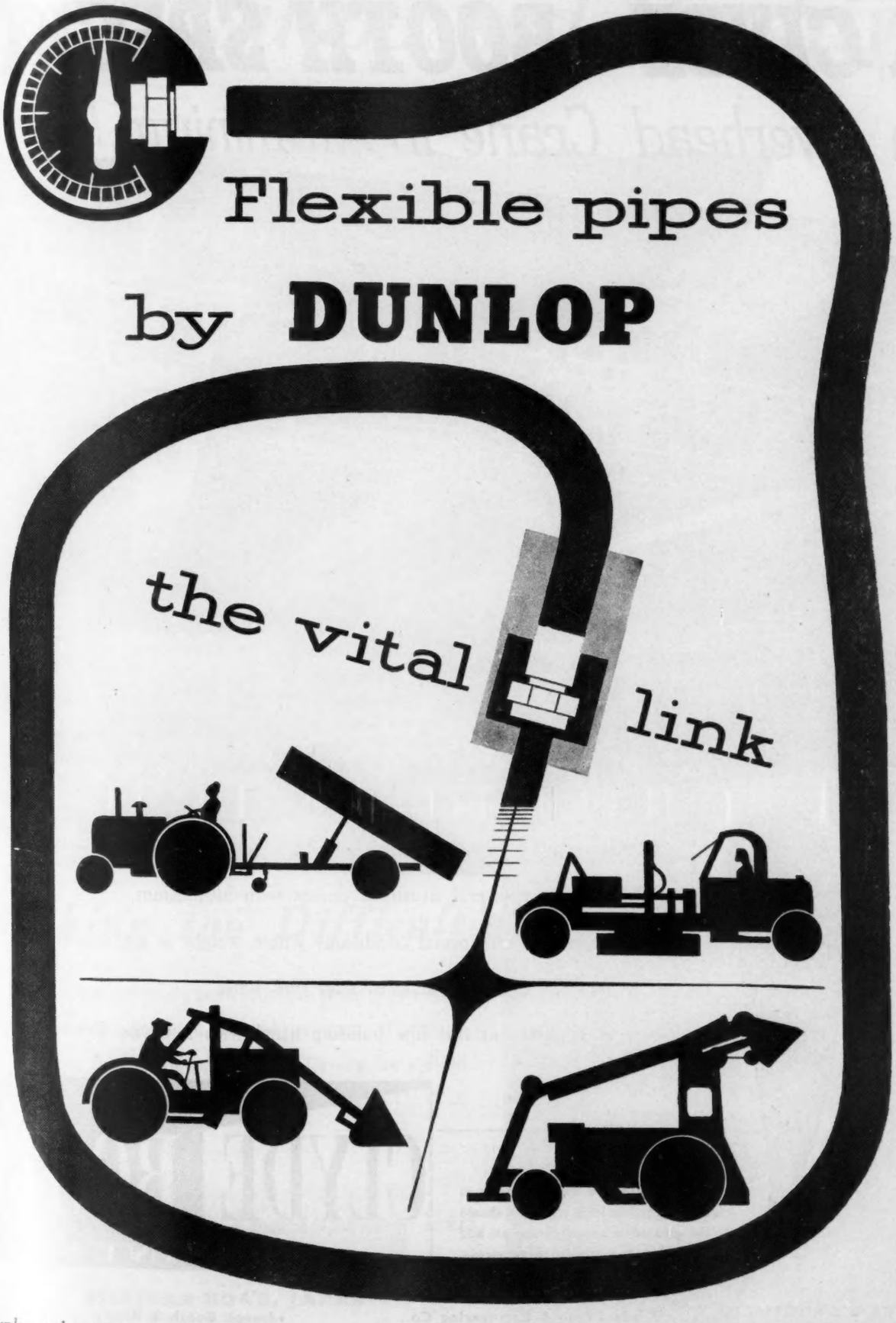

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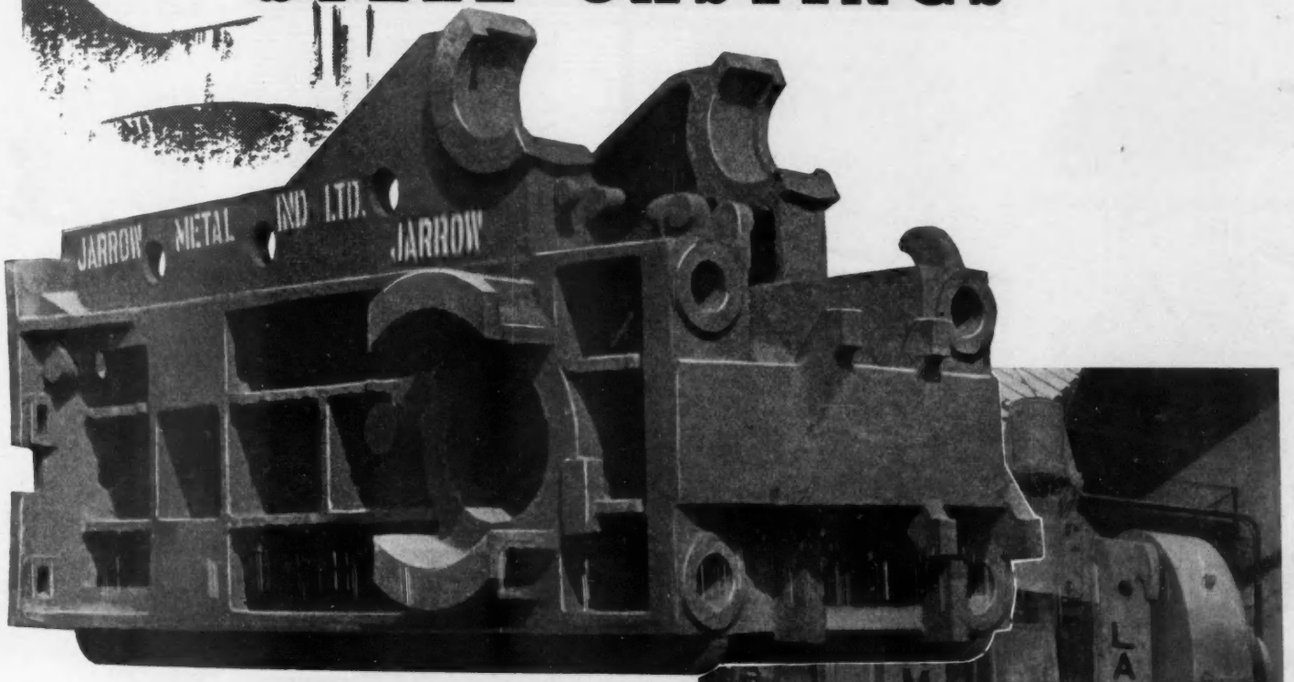

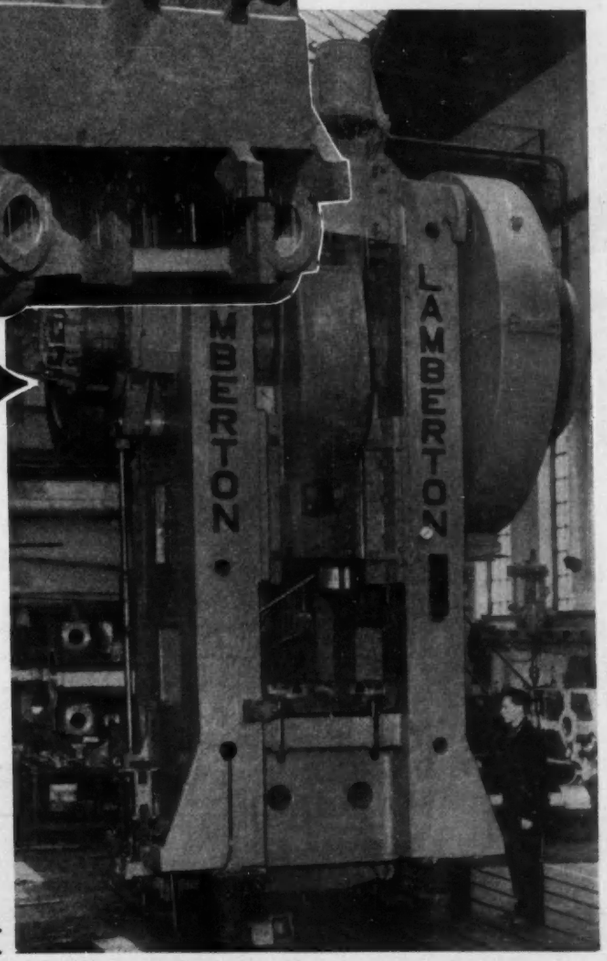

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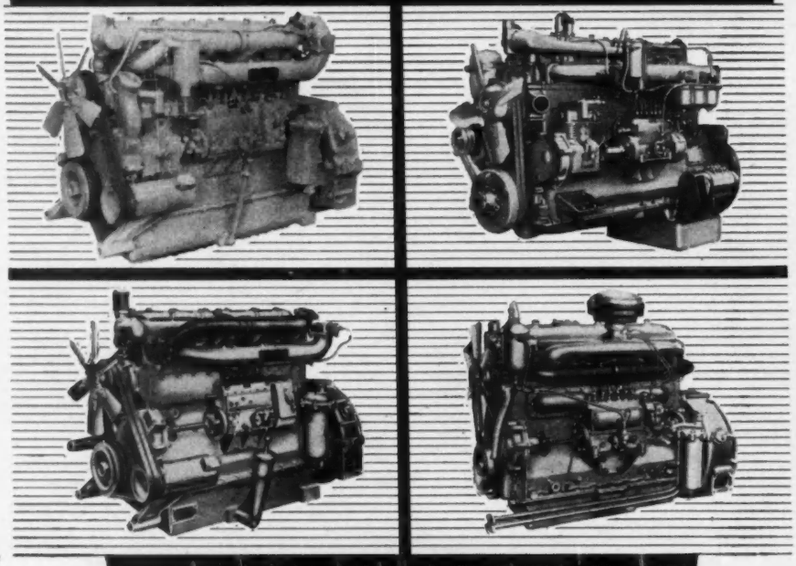

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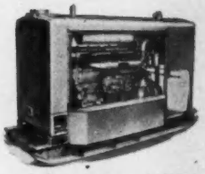

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BLAW-KNOX BK-12 MOTOR GRADER.

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600 Vertical or Horizontal	4.8 in. (121.92 mm.)	5.5 in. (139.7 mm.)	597 cu. in. (9.8 litres)	1,625 lb. (738 Kg.)	125 b.h.p. at 1,800 r.p.m.	112.5 b.h.p. at 1,800 r.p.m.	92 b.h.p. at 1,600 r.p.m.
680 Vertical or Horizontal	5 in. (127 mm.)	5.75 in. (146 mm.)	677 cu. in. (11.1 litres)	1,640 lb. (744.5 Kg.)	150 b.h.p. at 2,000 r.p.m.	135 b.h.p. at 2,000 r.p.m.	115 b.h.p. at 1,800 r.p.m.
900 Vertical or Horizontal	5.5 in. (139.7 mm.	6.5 (165.1 mm.)	927 cu. in. (15.2 litres)	2,580 lb. (1170.2 Kg.)	200 b.h.p. at 1,840 r.p.m.	170 b.h.p. at 1,800 r.p.m.	142 b.h.p. at 1,600 r.p.m.

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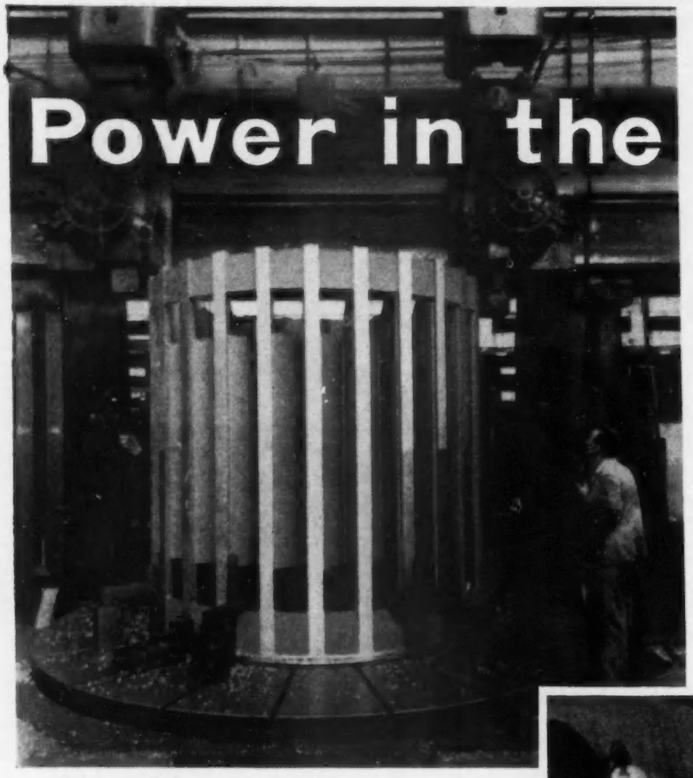

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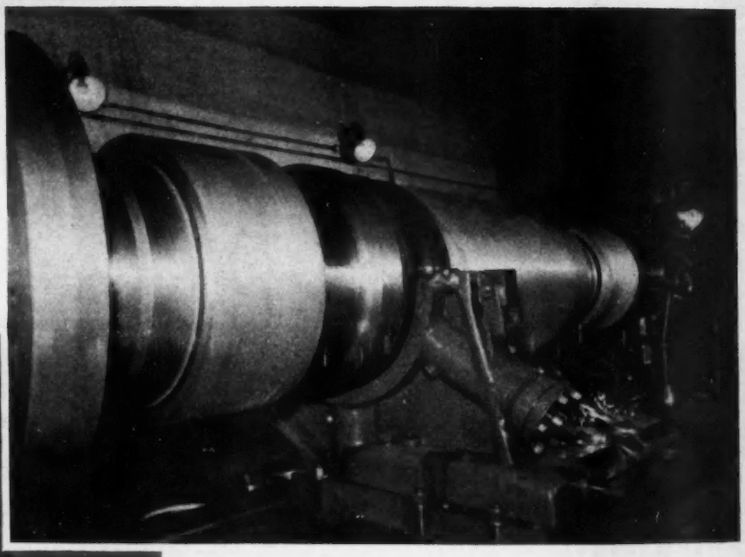
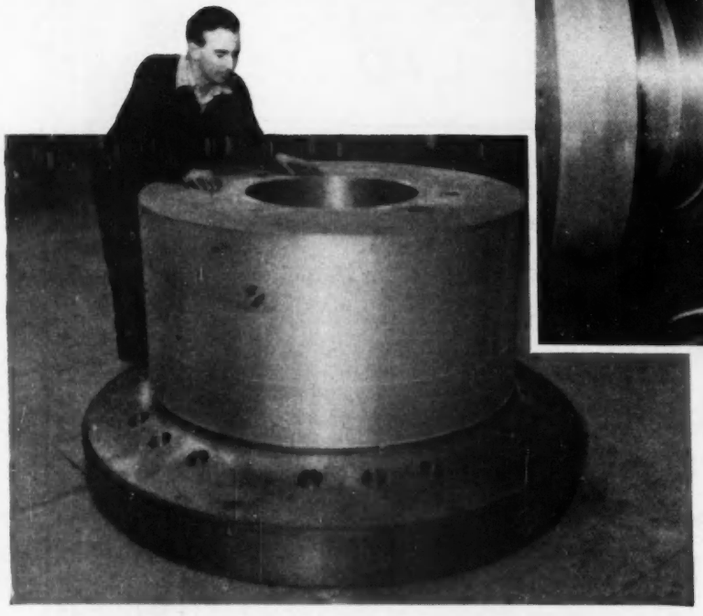


Machining the rotor shaft. The completed rotor will weigh 300 tons.



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ENGINEERING

An Illustrated Weekly Journal

Vol. 181 No. 4706 MAY 18, 1956

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FREEDOM FROM GOSSIP

THOSE nationalised industries which were nationalised as a result of years of pent-up political feeling—the railways and the coal mines particularly—have given the least satisfaction to the nation. Conversely, those which were nationalised for no better reason than that it was the policy of the Labour Party—the air-lines, electricity and gas—have given the least cause for uneasiness. This is not as paradoxical as it seems. The political feeling behind the railways and mines could not be dispelled over-night by the Acts of nationalisation; it has persisted. It will die out slowly, as a new generation of railwaymen, civil servants and politicians takes over, but the process would be hastened by allowing the railways and mines as much freedom as possible from political gossip.

If there is any hope for such freedom it is very slender. A workable system of accountability to Parliament for the nationalised industries has still not been evolved. Last week the Prime Minister announced his intention to appoint a new Select Committee on the Nationalised Industries. It is the fourth committee to be appointed, the other three having failed, for various reasons, to produce acceptable results. The new committee's terms of reference are as wide as they could be: "To examine the reports and accounts of the nationalised industries whose controlling boards are appointed by Ministers of the Crown and whose annual receipts are not wholly or mainly derived from moneys provided by Parliament or advanced from the Exchequer." These terms will apply to the British Transport Commission, the British Overseas Airways Corporation, the British European Airways Corporation, the National Coal Board, the Central Electricity Authority, the Gas Council, the North of Scotland Hydro-Electric Board, and the South of Scotland Electricity Board. But if the phrase "to examine the reports and accounts of the nationalised industries" seems to give complete freedom to the committee, a narrower interpretation is to be applied in practice.

The Prime Minister has said that wages and labour conditions negotiated between the unions and the industries "are certainly not points that could be settled by the Select Committee." He has also said, quite rightly, that Ministers will not be required to appear before the committee, since they are responsible to the whole House of Commons. It has been suggested, too, that in consequence, decisions of Ministerial policy cannot be very well argued before the committee. And if, finally, matters of day-to-day administration are excluded from the committee's review then, in the words of *The Times*, "the barriers will be up again and the new committee will encounter the same difficulties as the old."

All this is little comfort to the people who work in the nationalised industries, or to those who do business with them. Both employees and customers want to see vigorous nationalised industries. How can vigour be assured? Clearly it cannot emanate from Parliament; not because Parliament does not contain some practical and energetic minds, but because its constitution and history have fashioned it into an effective agency of democracy, not into a tool for directing vast enterprises. Still less can the vigour come from the Ministries; that is an assertion which needs no proof. It is, of course, the board from whom the vigour and spirit of a nationalised industry must flow. And it is the appointments to the board which Parliament should watch and review, rather than the past working of the industry as set out in detail in the annual report, or its future policy as proposed in unimaginative detail by Members of Parliament.

It is, however, a convention of the House rarely to discuss the Ministers' appointments to the boards. If this convention were to be abolished, and the House were to concern itself more with the appointments and with the structure of the nationalised industry boards, there might be some possibility of focussing discussion on the fundamental issues. These are the only issues which the House, or its Select Committee, can usefully delve into. Can this counsel of perfection be followed? No Member will lightly forego his right and duty to speak on behalf of the local interests of his constituents. Yet it is just this type of gossiping inquiry which makes a farce of the accountability of the industries to Parliament. If there is a proper place for airing local criticisms it is in organisations such as the transport users consultative committees, not in Westminster.

It should not be too much to hope that Parliament will eventually evolve a satisfactory procedure. As it was the Labour Party which started the trouble anyway, they would be doing a great service if, with the freedom enjoyed by the Opposition, they were now to perfect their post-war nationalising efforts by putting forward a procedure that will abolish the political muddle that has repeatedly frustrated the nationalised industries. If they cannot, or if the Conservative Party cannot, a great number of people employed in the industries will never be able to give of their best, and the nation will have to carry its basic services. If they can, it will be just possible for the boards, given adequate time, to rebuild their industries. "Just possible" because there is no denying

that the task of organising some of the largest employers of labour in the country is enormous. No self-appointed critics can do it, Parliament cannot do it, the Press cannot do it. Only the boards can do it. They must be the right men (some already are) with the right kind of backing.

* * *

Plain Words

On Monday this week a London evening newspaper came out with the headline "Automation: 'Keep Calm'." The journalist in us reflected that a technical word which can reach the same horror level as the word "Hitler" reached sixteen years ago must surely have reached the zenith of its power to stir the emotions. A word which is so little understood cannot hold the headlines much longer.

We then examined the phrase as engineers. We wondered whether, when the dust has settled, the climate of public opinion will be clear enough for progressive, level-headed engineers to continue with their traditional role of enabling the people to work less and consume more. Many readers of this column will have an advantage over us because they will read it a week or two hence, when all the dust, surely, will be on the ground. If, by that time, these plain words have been shown to be false, let them write and tell us to eat them—plain fare never did anyone any harm.

How ironical it is that the word which means the application of power-controlling power should get completely out of control in this country during the past few weeks. There has been no one big enough, or bold enough, to step out from the mob and catch the reins of this runaway horse. There are, indeed, few men in the public eye who are so universally respected that they could set the word back in its proper place. Perhaps only one man—he who sixteen years ago was telling us where Hitler belonged. The shortage of scientists and engineers has been known among the professions for at least ten years, but it was only when Sir Winston Churchill referred to it a few months back that the country became alive to the situation. Now, perhaps, he could allay the misplaced fear of automation, dispel the nonsense, restore the sense of security, and still leave the word intact, so that engineers can resume their job of applying it methodically and gradually.

Those engineers of firm purpose who refuse to be deflected by the current distortion will find an adequate review of the problems in the D.S.I.R's report on automation published this week. In addition to the management and labour aspects, it sketches the major technical developments and gives a long bibliography of published articles. An article too recent to be included but of special value is that by Sir Walter Puckey, which we published four weeks ago. When he wrote it Sir Walter foresaw the reaction against automation that might set in after the adulation. More than ever, clear thinking on automation will be needed in the future.

AN OLD INDUSTRY DEVELOPS TECHNICALLY

FURNITURE DESIGN AND PRODUCTION

By J. C. Pritchard

The furniture industry is changing rapidly. The old hand-craft method of production has been increasingly replaced by machine production. Scientific methods are beginning to supplement tradition and experience. The size of the successful manufacturing unit is growing and modern thoughts on management are beginning to have an increasing influence. Furniture design is being improved to meet the needs of a mass market and those who make up this market are becoming more discriminating.

STRUCTURE OF THE INDUSTRY

The furniture industry is very different in structure from some of its chief competitors supplying durable consumer goods. In the domestic furniture industry there are nearly 2,500 firms. The 50 largest firms share about 40 per cent. of the market. The point is made in more detail by the figures in Tables I and II, which also show the changes during the past six years.

Compare these figures with those of the motor industry, with its five large and a dozen or so small producers, and with the six large producers of radio and television sets. They are new industries based on science and engineering.

TABLE I.—*Distribution of Firms in the Furniture Industry: Percentage of Firms (size measured by turnover).*

Turnover	1950	1952	1954
Under £1,000	21	20	16
£1,000—£9,999	32	32	28
£10,000—£49,999	28	28	28
£50,000—£99,999	10	9	12
£100,000—£499,999 ..	8	10	14
£500,000 or over	1	1	2
	100	100	100

TABLE II.—*Distribution by Percentage of Market.*

Turnover	1950	1952	1945
Under £1,000 ..	4	3	2
£1,000—£9,999 ..			
£10,000—£49,999	18	15	10
£50,000—£99,999	16	13	11
£100,000—£499,999 ..	40	42	37
£500,000 or over	22	27	40
	100	100	100

Source: Furniture Development Council.

SHARE OF CONSUMER MARKET FOR DURABLE GOODS

These new industries are producing for the mass market products that were hardly known 40 years ago and, as a result, the furniture industry has lost its predominant position as a supplier of durable consumer goods. During the last few years its share of consumer expenditure has remained steady at about 3½ per cent., but furniture consumption, i.e., the volume of furniture bought measured against size of population, has during the last few years averaged less than 75 per cent. of the pre-war (1938) figure. This is a basic problem of the industry. The state of transition through which it is now passing is partly an attempt to find an answer. Before the war there were only a few firms in the furniture industry whose management appreciated the need to use new methods to the fullest extent. Their leadership is helping the industry to face up to the present situation and there is a growing realisation that its main competitive problems are concerned with competing as an industry for its share of the consumer purse.

To achieve an increased share of the market requires one or both of two factors: an increased demand stimulated by publicity, and increased value for money as a result of improved production efficiency. Consumer advertising, with a few notable exceptions, is comparatively new in the furniture industry. But during the last few years there has been a significant advance in the interest shown in new production methods, and those firms who have been applying these new methods are rapidly moving ahead. The value of production per worker is increasing.

Progressive firms in the furniture industry have achieved an effective alliance of pleasing design and quantity production.

METHOD STUDY AND COSTING

One manifestation of the demand for improved methods has been the increasing use of a series of new services that have been set up in the furniture industry. These include advice on costing, method study training, research and technical information services. These services have been started in the first place by the Furniture Development Council, with the firm support of leaders in the industry who recognise the importance of raising its status and the need for the industry as a whole to compete more effectively. One important development has been the comparative cost scheme, which is increasing in value as more firms join and as comparisons over time become possible. It should become an important tool of management control. Method study is being increasingly employed in both large and small factories, and method study courses are being run by the industry. Its courses are attended by all grades of workers and management, and, more recently, by design students.

TRAINING AND EDUCATION

There has been very little attempt to provide the industry with education and training at levels other than the City and Guilds craft courses. These courses, however, are strongly supported both by the unions and by management and there is an effective day-release scheme for learners to attend these courses. The figures of attendance show that the number taking advantage of existing facilities as a percentage of employment has risen from 3·8 per cent. to 5·3 per cent. in the past five years.

Meanwhile among the more progressive firms the demand for training at a level comparable to,

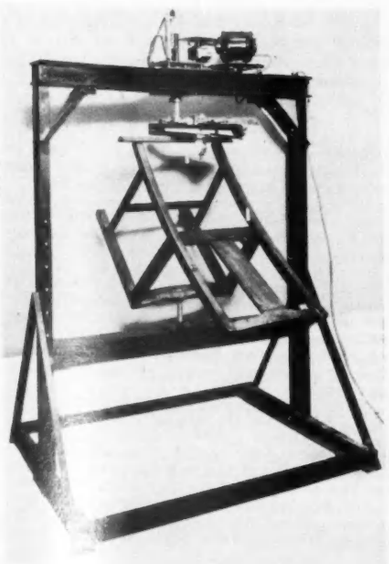
say, that required by the Institution of Mechanical Engineers for membership is increasing and series of advanced courses are being actively considered. In such firms the prospects for young people with technical qualifications are good.

TECHNICAL DEVELOPMENTS

Probably one of the most significant technical developments in furniture production in recent years has been the introduction of synthetic resin adhesives combined with the use of dielectric and other heating methods to accelerate their setting. This change has meant that whereas before it was necessary to wait for some considerable time "for the glue to dry" it is now possible to set the joints hard in a very much shorter time. The change has led to greater efficiency in the flow of production.

The use of plywood in furniture has increased considerably and now chipboard is being developed as a basic raw material. There has also been an increasing use of foam rubber in upholstery, and in some cases rubber webbing is being substituted for springs.

The industry's principal raw material is, and is likely to remain, timber, representing something like 25 to 30 per cent. of total factory cost, and it should be noted that over 80 per cent. of all timber used in the industry is imported. Before the war a large proportion came from the U.S.A. in the form of well-graded oak. Since the war, soft currency areas (West Africa and Finland) have replaced the hard currency (Canada and the United States) as the chief sources of supply. Timber costs have risen by approximately 500 per cent., since 1938, against a rise of approximately 250 per cent. in the cost of furniture. The efficient use of timber is one of the most important problems in the industry, and the Forest Products Research Laboratory at Princes Risborough has carried out and is carrying out a very great service to the industry. One important aspect of this work is concerned with the conditioning of timber, and its work on kilning has been invaluable. Efficient kilning not only helps the industry to make good-quality furniture but also helps a quicker turnover of timber stocks. The Laboratory has a considerable programme of research that has a direct bearing on the furniture industry. For example, one important item in its programme of work is that on timber bending, and although the use of bent timber in the furniture industry is an old craft, research has been able to suggest a number of new and improved methods.



This machine for simulating users' treatment of chairs is typical of the test rigs which have been introduced by the Furniture Development Council's research laboratory.

FURNITURE RESEARCH

The industry now has its own research laboratory. One of its first jobs was to provide a simple method of testing furniture. These simple tests have been incorporated in a British Standard and provide the inexperienced housewife with an assurance of durability. The tests are now being used to an increasing extent by individual firms in the development of new methods of construction.

The research laboratory in its long-term work is concentrating on the use of material. Before the war the cost of material as a percentage of factory cost may have been in the order of 25 or 35 per cent. To-day it is 50 or 60 per cent., and, as we have already seen, timber alone is at least 25 per cent. The importance of concentrating on efficient use of material in the construction of furniture is therefore clear. This work has made some progress, first in establishing *quantitatively* the relative effectiveness of various components in cabinet furniture. Much of this work has simply confirmed past good practice, as no doubt the first theoretical work on roof trusses confirmed the wisdom of most of the medieval builders. The result of this research into furniture construction will provide the furniture designer with the type of information that is now essential for the architect and engineer when designing roof trusses, bridges and other structures. As the work proceeds it is hoped that the industry will also be provided with further information enabling it to use its costly raw materials more and more efficiently.

The character of furniture is likely to be increasingly affected by the new materials. Research work is being carried out to see how some other new materials might be of use to the industry, but where tradition exerts a strong influence, as it does with furniture, timber is likely to prevail over the synthetic materials for many years to come and new materials are more likely to be used in the process of manufacture than in substitution for timber and similar traditional materials.

MORE DISCRIMINATING PUBLIC

As the standard of living rises, the public become more interested in furniture and more discriminating. With the probable increase in Press advertising this process will continue and more thought will be given by the public to furniture and the home scene generally.

The character of furniture is already changing rapidly. Those who have visited the Furniture Trades Exhibition at Earl's Court in each of the last three or four years will have seen the change taking place. The changes were particularly noticeable at the recent Exhibition. In the past it has been the small firm selling in the higher price range that has been able to try out new ideas in design, and the large firm, needing full production runs, has usually to move more cautiously in designs in a market where tradition is firmly established, but recently the demand for new designs has increased and large firms are producing at low prices fine modern furniture.

Good furniture is an essential element of good living. The rising standard of living which we all expect should provide a fine opportunity for the furniture industry. Though faced with great competition from the automobile and electrical appliances industries, the furniture industry, using its new techniques of production, its new materials, and its better standards of design—by giving the customer value for money—can face this future with confidence.

ATOMIC REVIEW

Progress in the field of atomic energy is rapid and continuous and activity in recent weeks has been no exception. Following the talk at Harwell by Academician I. V. Kurchatov on the possibility of achieving controlled thermonuclear reactions (see the last issue of ENGINEERING), there have been some further revelations on the subject from the Soviet Union. In addition, a number of reactor schemes and projects have been proposed and Mr. H. G. Davey, works general manager, Northern Area (Industrial Group), U.K.A.E.A, has spoken on maintaining nuclear reactors.

Thermonuclear Reactions

The publication in Britain of a paper dealing with an important aspect of Soviet research might lead one to suspect that this particular line of research had drawn a blank. But in spite of the openness displayed by Academician I. V. Kurchatov in his talk at Harwell "On the Possibility of Producing Thermonuclear Reactions in a Gas Discharge" and the very considerable problems he revealed, it would be unwise to dismiss the method described on that occasion as impracticable without further knowledge. This technique has one fundamental advantage. The means of containing and insulating the high temperatures required are essentially the same as the means by which they are produced—the current that heats can also be controlled by a magnetic field. This technical economy is very attractive.

No similar economy seems possible with the methods to which Academician Kurchatov has since referred in an article in *Pravda*. These, it appears, make use of gas explosions, and the problem of containment must be quite serious, since temperatures of a million degrees Centigrade and more are again necessary and this time there is presumably no electromagnetic means of insulation. The article in *Pravda* seems to suggest explosions between heavy hydrogen gas and oxygen. Research on the production of high temperatures in gases through the use of shock waves from explosions has recently been reported by the Los Alamos laboratory of the United States Atomic Energy Commission, but the highest temperature reached fell far short of that achieved in the Soviet gas-discharge experiments.

Reactors

Recently published information on nuclear reactors includes an account of the way in which the Windscale piles are maintained; a description of reactor systems using fluidised solids; the announcement of a United States high-temperature homogeneous reactor project; and further details of OMRE (Organic Moderated Reactor Experiment) also to be built in America. Other reactor news includes the construction of a reactor in India, the extension of the Norwegian reactor at Kjeller, and the use of reactor simulators in Britain.

ORGANIC MODERATOR

Fig. 1 shows the layout of a reactor using as moderator and coolant the organic compound, diphenyl, which will be in liquid state when the reactor is operating. It is to be built by Atomics International, a division of North American Aviation, Incorporated, Los Angeles, at the U.S. Atomic Energy Commission's reactor testing station in Idaho, and is scheduled for completion late this year. The plant, which includes a still (at right of illustration) to purify the carbon-hydrogen compound for re-circulation, is expected to develop about 16 MW of heat, but this will not be converted into electrical power. The organic system, however, is specially suitable for small-capacity power plants and OMRE will serve as a source of data for future installations of this kind. The reactor core will consist of plate-type fuel elements highly enriched in uranium 235. The use of an organic coolant offers the following advantages: its large hydrogen content makes it an excellent moderator; it boils at much higher temperatures than water and therefore need not be under pressure; it causes negligible corrosion of standard construction materials; it does not react readily with uranium; and it becomes only slightly radioactive when exposed to nuclear radiation. The problems to be solved are concerned chiefly with the effect of heat and radiation on the organic compound, which tends to deteriorate, and it will be necessary to determine the irradiation and thermal stability of organic coolants under anticipated power-reactor operating conditions. Contingent upon the success of OMRE, Atomics International are to be design agents for a 12·5 MW electrical-capacity organic-moderated plant proposed by the city of Piqua, Ohio, in connection with the U.S.A.E.C's Power Demonstration Programme. It would be completed by 1960.

Early this month the U.S.A.E.C. announced that they had signed a contract for the design and construction of an experimental homogeneous power reactor to use a uranium solution in liquid bismuth

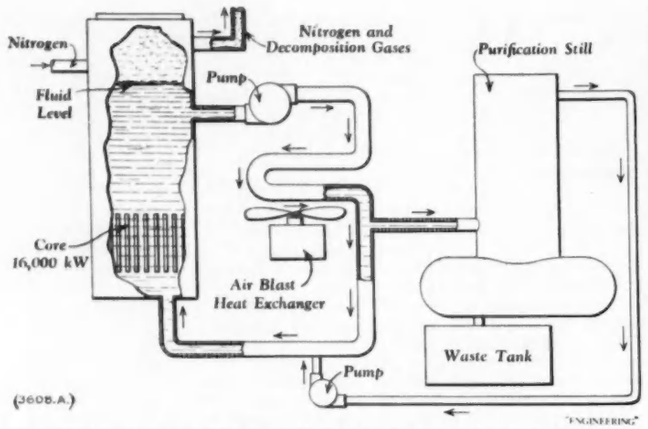


Fig. 1 General layout of a reactor system employing an organic material diphenyl as coolant and moderator. An experimental reactor, OMRE, based on this principle is to be built in the United States by Atomics International, a division of North American Aviation, Incorporated.

as fuel and moderator. The reactor should therefore be able to operate at high temperatures and low pressures, and be able to produce steam under conditions comparable with those in conventional coal or oil-fired boilers. The Westinghouse Electric Corporation of Pittsburgh, Pa., in conjunction with the Pennsylvania Power and Light Company, have also recently stated that they are to build a homogeneous reactor. It will be financed entirely by the two companies, is expected to begin operation in 1962, and is designed to have an output of 150 MW.

Since the end of March, the British Nuclear Energy Conference has held five meetings under the aegis of one or other of its constituent institutions, and the papers presented have been largely concerned with reactor design and maintenance.

TABLE I. *Classification of Possible Systems for Fluidised Thermal Nuclear Reactors*

—	Reactor type			
	I	II	III	IV
Solid	M	F + M	F	I
Fluid (gas or liquid) ..	F	I	M	F + M

M = moderator; F = fissile fuel; I = inert material.

TABLE II. *Possible Fluids for Use in Basic Types of Reactor*

Reactor type	Type of fluid	Possible fluids	
		Liquid*	Gas
I	F	Solution of U in Bi	UF_6
II	I	Na, Bi, Li^7	CO_2, H_2O, H_2, He
III	M	H_2O, NaOH, Dowtherm, terphenyl	(CO_2, H_2O, H_2)†
IV	F + M	solution of U in H_2O	None known which is feasible

* D_2O could be substituted for H_2O in this column and NaOD for NaOH.
† These would be gaseous moderators and are included for completeness rather than feasibility.

Fig. 2 Device used at Windscale for remotely controlling the movement of an oxy-acetylene torch inside a reactor, where hazards of radioactivity or inaccessibility prohibit normal working.

At a meeting sponsored by the Institution of Chemical Engineers, a paper entitled "The Application of Fluidised Techniques to Nuclear Reactors" was delivered by Dr. J. B. Morris, Mr. C. M. Nicholls and Mr. F. W. Fenning. If gas or liquid flowing at a sufficient velocity is passed through a bed of powdered solids resting on a grid, the solid particles will be lifted and supported in such a way that they will have no permanent contact with one another and the bed will in fact resemble a liquid in constant agitation. It is conceivable, therefore, that a reactor can be designed having fuel, moderator and possibly some additional inert material in the form of the fluidised solid or the fluidising gas or liquid. Possible arrangements are given in Table I, while some feasible materials for use as fluids are listed in Table II. The advantages of such a technique are: favourable heat transfer; even temperature throughout the reactor; and, assuming that mutually compatible fuel, coolant, materials of construction, and moderator can be devised, the avoidance of costly fuel-fabrication operations. Features that might be suspect are: the safety of the system—escape of radioactive dusts or sprays could be extremely dangerous; erosion and corrosion; and the investment in fuel—this may be high either in the case of a batch fluidised bed or in the reactor and heat exchangers if the fuel is transported as well as fluidised.

Four principal systems are feasible with gas as the fluidising medium. In the first three the bed is suspended in the reactor but not circulated by the gas, the gas being in cases one and two the heat transfer medium. In case one the hot gas is carried directly to a closed-cycle gas turbine; in case two it goes to an external heat exchanger; and in case three, the heat exchanger is situated within the fluidised bed itself. The fourth system involves the circulation of solids in a closed cycle from the fluidised bed to a heat exchanger and is shown diagrammatically in Fig. 3. In this case the heat rating is given by $Q/S = C_s \Delta T$, where Q is the reactor heat load, S is the mass rate of circulation of the solid, C_s is the specific heat of the solid, and ΔT is the temperature drop of the solids in passing through the heat exchanger. It seems possible that heat loads exceeding 100 MW could be obtained, but wear and tear would be considerable and the hazard of escaping particles serious. Liquid fluidising agents could of course also be used for certain of these systems. A Netherlands design for a reactor using fluidised solids was mentioned in our article last year on "Power Reactor Projects Throughout the World" (ENGINEERING, vol. 180, page 490, 1955).

REACTOR MAINTENANCE

An important conclusion to be drawn from the paper "Some Problems in the Maintenance of Nuclear Reactors" presented at the Institution of Chemical Engineers on May 3 by Mr. H. G. Davey, O.B.E., works general manager of the Northern Area (Industrial Group), U.K.A.E.A., which includes the Windscale plutonium factory, is that in spite of radiation hazards a nuclear reactor can be built to allow systematic maintenance, and that this factor will play a significant part in future reactor design. He described ingenious methods of maintaining nuclear reactors and said that reactor maintenance was in itself a relatively simple mechanical operation, but the circumstances in which it was carried out were complicated by inaccessibility or radioactivity. Television cameras (see ENGINEERING, April 27, page 282) periscopes and introscopes had been used for inspecting damage, and new w[illegible] had been devised for cutting out steel plates [illegible]h remotely controlled oxy-acetylene equipment [illegible]Work had sometimes to be carried out from a dis[illegible]ce of 60 ft. Fig. 2 shows an arrangement of an [illegible]xy-acetylene torch for remote control. On the [illegible]ght of the torch, outside the illustration, is a lam[illegible], and on the left an introscope. All three items [illegible]re lowered from above, the torch sliding down [illegible] length of tubing. The torch nozzle is bent at r[illegible]ht angles to the plane of the page and passes through a small plate. The plate slides on an arm under the control of a wire and spring, and a second wire governs the movement of the arm. Mr. Davey said that reactors of the future would be designed to simplify such remote operations and that at all times accurate drawings should be available, even of those parts that at the time of design were regarded as inaccessible, so that problems of maintenance could be tackled promptly. Temporary shielding should be designed for use in confined spaces and mock-ups prepared to represent working conditions.

RESEARCH AND SIMULATORS

An agreement has recently been signed between India and Canada for the erection, under the Colombo plan, of a high-powered research and experimental reactor at the Indian Government's establishment at Trombay, near Bombay. The construction of the plant, which will be similar to a Canadian installation at Chalk River, is to be a joint project, but the reactor will pass to the Indian Government on completion. It is also announced that the capacity of the Norwegian reactor at Kjeller, near Oslo, is to be increased from 350 kW to 800 kW. This will be achieved without rebuilding the reactor. There will be changes in the heating system and the secondary coolant circuit to make the expansion possible.

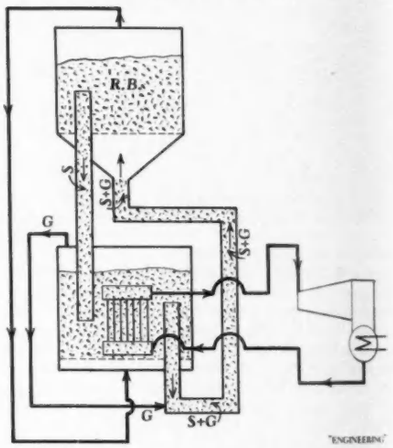


Fig. 3 The use of fluidised powdered solids in a reactor for coolant, moderator, or fuel, or all three, may give efficient heat transfer and uniform temperature throughout the reactor core.
(RB = reactor bed, S = solids flow, G = gas flow, and S + G = combined solids and gas flow.)

A reactor development laboratory for use by industry and Government in the study of reactors for power production and propulsion has been completed at the Battelle Institute's research centre, Columbus, Ohio. The new unit is a critical assembly laboratory and will provide for the operation of reactor cores at zero powers. It is the second major unit to be installed at the Institute's atomic energy centre; the first was a hot cell laboratory, which began operation last September, and the third will be a swimming-pool reactor, which should be in operation later this year.

The artificial representation of reactor operation can be useful both as a means of training operators and for solving design problems. Thus reactor simulators in which functioning controls and instruments correspond to those of an actual reactor control desk have been used for instruction at Harwell. A unit of this kind has also been shown at the British Industries Fair. Of a more complex nature is the analogue computer which Elliott Brothers (London) Limited are building for the General Electric Company, Limited. Designed to G.E.C. requirements, the machine will be used for investigating reactor power station kinetics and will be specially applicable to gas-cooled graphite-moderated systems; however, its flexibility will also permit its use in the design of other kinds of reactor.

Letters to the Editor

TESTING CONCRETE QUICKLY

SIR, May I make a brief reply to the letter of Mr. T. N. W. Akroyd and Mr. R. G. Smith-Gander published in your issue of April 27.

Firstly, I must disclaim all responsibility for the title above the published edition of my letter in the issue of April 6, and indicate further that I did not at any time write of a steam bath, although I did mention the old fashioned "steamer" which is in principle a steam-heated enclosed chamber.

Secondly, I regret that the only point wherein I showed definitely that the oven method was superior, in that scatter with different cements was much less than by the hot-water method, was ignored in the reply by Messrs. Akroyd and Smith-Gander. That, after all was by far the most important criticism and does point out a very serious drawback in their method.

Yours faithfully,

J. W. H. KING.

Queen Mary College,
London, E.1.
May 7, 1956.

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ENGINEERING FIRMS IN THE NEW TOWNS

SIR, I was interested to read your article on the New Towns, with its references to Crawley, and think that the following facts may be of interest.

Firstly, although I have always joked with the Crawley Development Corporation about their high rents, I have always complimented them on the extremely pleasing layout of the industrial site, and also complimented them on the good job they have made of a very difficult problem in the housing of so many people. Of the first four original tenants, my firm included, three have now doubled or more than doubled the area of their works. Of the next batch of tenants of standard factories, one firm has also increased the size of its factory. This proves that our foresight in moving out of London has been worthwhile.

We work in a country atmosphere with plenty of open space to breathe, among trees and grass and flowers. I have always felt that although we have to work for a living, there should be no need to work in squalid and unpleasant conditions, such as occur in so many industrial towns.

Yours faithfully,

for Vaughan Lift Engineering Limited,
J. H. VAUGHAN,
Managing Director.

Gatwick-road,
Crawley.

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Obituary

DR. OSCAR FABER, C.B.E.

An Engineering Controvertist

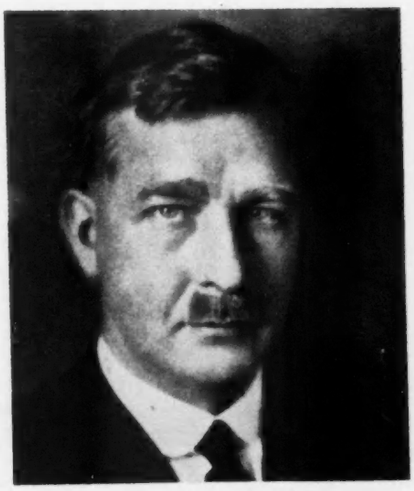
For just on 50 years Dr. Oscar Faber has been a force in engineering. Now, with his death on Monday, May 7, in hospital at Bedford, following a heart attack at the age of 69, there has gone one of the most controversial figures among British consulting engineers. Author of many books—his "simply explained" series for structural engineers are to be highly recommended to the young engineer and student—a lecturer who had delivered papers at a number of the institutions and had contributed to the discussions of a great many more, Oscar Faber succeeded in becoming one of the best-known of the consultants.

He was one of the intrepid few who have achieved full membership of all three of the senior institutions—though the third part of that triple crown, the M.I.E.E., was achieved only so recently as last year. He had enjoyed the Presidency of the Institutions of Structural Engineers and of Heating and Ventilating Engineers, the former as long ago as 1935 when he was less than 50 years of age. His supervision of the design and construction of the Bank of England buildings before the war, and later of the new House of Commons, brought him to the forefront of the profession. He was, during the last war, specially flown to the first Quebec conference in the summer of 1943, to advise Mr. (as he then was) Winston Churchill on the Mulberry harbour projects, which were to be one of the more significant contributions to the success of the invasion of the European mainland in the following year. Yet the highest honours escaped him. He never reached the council chamber of the Institution of Civil Engineers, thus to be in running for that Presidency, an office which at one time his friends and admirers must confidently have predicted for him. In the Honours Lists of 1951, he received no more than promotion from the O.B.E. to which he had already been appointed some 35 years, to a C.B.E. A vigorous, outspoken man, Faber was never able to hold his tongue when he felt—as he often did—that he could make a positive contribution to the matters in hand.

Oscar Faber was born on July 5, 1886, the son of Harald Faber, the Danish Commissioner for Agriculture in London, and received his general schooling at St. Dunstan's, Catford, followed by an engineering education at the City and Guilds College, South Kensington, where he graduated a B.Sc. in 1906. On coming down from college, he was immediately introduced to the problems involved in the then new medium of reinforced concrete and within a few years had gained a D.Sc.(Eng., Lond.) for a thesis entitled "Reinforced Concrete Beams in Bending and Shear," and had published his papers on plastic yield and shrinkage in concrete, which were to remain the most authoritative work on those topics for more than 20 years.

An exception in so many ways, Dr. Faber was one of the few successful consultants of his generation who was never articled to his profession. His first appointment, directly on leaving college, was as an assistant engineer with the Associated Portland Cement Manufacturers. This was followed in 1909, in a post of a similar capacity, with the Indented Steel Bar Company, where he remained until 1912, when he was appointed, still at the age of only 26, as chief engineer of Trollope and Colls, Limited, with whom he remained until 1922. In the course of an interlude from civil engineering during the first World War, for work connected with magnetic anti-submarine mines, he was awarded his O.B.E.

In 1922, he set himself up in practice as a consulting engineer and it was in this capacity that he undertook much of his most important work, including the responsibility for devising the complex ventilating plant and reconstruction of the House of Commons. Indeed, as an engineer much of his work was closely connected with that of the architect—large massive buildings for the head offices of banks and insurance companies both at home and abroad, including the Far East. His approach was not limited, however, to the simple structural aspects of the building. Durham University conferred the degree of D.C.L. on him for his timely work in underpinning and restoring Durham Castle. He had a high regard for the appearance that would be the result of his work, and his views on the subject were given in a paper to the Civils entitled "Aesthetics of Engineering Structures," for which he received a Baker Gold Medal. Neither were his responsibilities limited to the civil engineering of the building for he concerned himself intimately with the installation of all the electrical and mechanical equipment.



Dr. Oscar Faber

A task to which he applied his particular attention was that of the design of hospitals, among the foremost of which may be mentioned the Middlesex Hospital in London, completed just before the war. At the time of his death, his firm were engaged upon the design of hospitals for Baghdad and Aden, and he was proposing to visit both those towns. His immediate plans had been for a trip to Siam where he was to arbitrate between the World Bank and a firm of contractors. Other well-known structures in the construction of which Faber had played a leading part were the cantilevered grandstands at Lords cricket ground and at Northolt racecourse, and the stadium at the White City.

But despite this full practice, Dr. Faber found time to investigate a number of problems which gave rise to difficulties in the day-to-day work of engineers. Shortly after the war, he evolved a formula intended to predict the load-bearing capacity of piles, the subject of a paper to the Civils. As characterised all his analytical work, the result was a formula that would have been simple to use. Unfortunately in the effort to gain simplicity, too many factors were ignored or regarded as negligible and the formula was one that few engineers cared to employ. To the Mechanicals, at about the same date, he delivered an all-embracing paper on the theory and merits of heat pumps.

For many years Oscar Faber had been chairman of the Code of Practice committee for reinforced concrete and had been a strong critic of the L.C.C. regulations for concrete-encased stanchions. Where his work had been beyond the reach of those regulations he often made use of lighter sections than would have been necessary in London, with a consequent saving in cost and, as he commented strongly, without any trouble ensuing. It was this problem that led him, within the last few years, to undertake the tests on Dorman Long's 1,200 ton compression machine of full-size concrete-encased stanchions with the object of having B.S. 449 amended. This work culminated in the paper presented, just before last Christmas, to a joint meeting of the Institution of Structural Engineers and of the British Constructional Steelwork Association. As those who were there will remember, several hundred structural engineers attended that meeting, attracted by the character and calibre of Faber. A slightly abridged version of the paper was published on page 855 of ENGINEERING for December 23, and readers will find this paper too was characterised by its intention to resolve an outstanding problem in a direct manner, readily usable in design.

During his earlier years Faber had been an enthusiastic yachtsman on the Norfolk Broads and, like many another successful man, was a competent painter, his water colours being used to decorate his own home. As a close friend wrote in *The Times* last week, "he was a prodigy of a man in his vitality, his zest for living, his capacity for work, his appetite for recreation. Big and heavy . . . untidy . . . eyes blue and clear . . . bushy brows over flaming cheeks, he always had something of the air of an untamed Viking. Character in him, as character often does, ran to eccentricity." And thus can be summed up this successful man who achieved so much but who might have been honoured so much more.

Weekly Survey

Cover Picture: *The chock shown undergoing boring and facing in our cover picture carries the flood oil lubricated roll-neck bearings in a four-high cold strip rolling mill recently built in this country for installation in Australia. The chock weighs approximately* 10 *tons and is for use on the large-diameter backing-up rolls of the mill. It has a width of* 28 *in., a length of* 76⅜ *in., and a depth of* 36 *in., and the diameter of the bore is* 34¼ *in. The rolling mill has been designed for the cold rolling of steel strip up to* 50 *in. wide at a speed of* 3,000 *ft. a minute.*

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Decision in Water Supply

" Most politicians, comedians, and managers are extroverts." This quotation—admittedly out of its context—is taken from a refreshingly attractive discourse on management given by Mr. Delwyn G. Davies at Malvern on Wednesday, May 9, on the occasion of the diamond jubilee celebrations of the Institution of Water Engineers. Though Mr. Davies, who is Water Engineer and Manager for Mid-and South-East Cheshire, was speaking more particularly about the water engineer in management, and his examples were taken from experiences gained in the water-supply service, his paper will be both instructive and amusing to all engineers who find that their activities encompass a broader field than purely technological problems.

The need for management at all was based, suggested Mr. Davies, on the conflicting requirements of an organisation as regards its need for skill in its employees and the available distribution of skill. The distribution of intelligence among the adult population could be represented by a sine curve—indicative of a small number of brilliant people, a similar number of defectives and a broad mass of normals—but an undertaking of any description demanded the more highly skilled in excess of the supply and was also bound by duty and necessity to use the partially deficient. For several reasons, though not necessarily connected with the foregoing, Mr. Davies found that in water supply the problems of management were accentuated. As in the former electricity supply industry, water supply had long been a province where the chief officer and manager had frequently been an engineer and, he believed, engineering training gave a solidly realistic foundation to co-ordinated thinking—a fundamental of good management, though of itself insufficient to infuse a common spirit into individuals.

Illogicalities had to be accepted and understood because they were human failings. Decisions had to be made, and great decisions could not wait for great men. Moreover, decisions were never judged when they were made; they were judged in the light of what followed, and the events invariably differed from those predicated. It was, observed Mr. Davies, the fundamental function of management to see round corners and to present all the facts in true perspective so that a policy-making board, composed probably of laymen, could decide the objective, which the chief official and his staff should then strive to attain with economy and dispatch.

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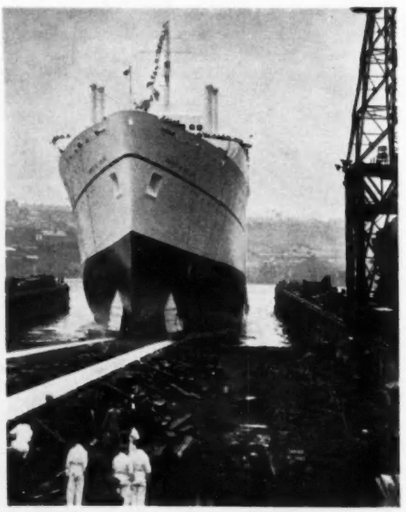
Automation in Water Supply

Water supply is one of the services which the public expects to be maintained without failure; in by far the majority of cases, that expectation is met. However, interruption of supply may by caused by meteorological conditions, which are uncontrollable, but, in addition, breakdown, or excessive or greatly reduced demand in some section of a distribution area, may derange the normal operation of a system, interfere with supply and necessitate remedial steps. These steps may be taken by attendant staff, but to ensure this men must be available on the spot. Labour is now very expensive and skilled and reliable men difficult to get and retain. These conditions have resulted in the application of automatic controls to many of the operations of water supply.

A series of papers presented at the meeting of the Institution of Water Engineers surveyed the whole field of " Automatic Operation of Waterworks Plant." Two topics are involved in this general subject: control is required to meet the pattern of demand or supply and, secondly, to deal with breakdowns or other emergency. The papers in the main dealt with booster stations but automatic controls can be, and are, adapted in main pumping stations, relieving the operating staff from much routine work and enabling them to give full attention to the maintenance of the plant in fully efficient condition. A point of importance is that automatic control ensures that remedial action, when required, shall be taken immediately; the human element will frequently not act so promptly or, if very conscientious, may act unnecessarily.

Control may be exercised in terms of pressure change in delivery mains or of water level in some source of supply. It may also be necessary in some cases to limit power consumption to the terms of a grid tariff. Safety measures may be designed to take care of breakdown of pumps or their driving motors, or of failure of power supply. Control may be mechanical, hydraulic or electrical. As in the majority of cases, especially in booster stations, pumps are driven by electric motors, final control will be exercised by some switch or contactor arrangement, but the electrical gear may in turn be controlled by a differential pressure in mains or by the level in a supply tank.

The papers dealt in considerable detail with booster stations on the supply systems of Nottingham, Oxford and Cambridge. Brief notes were also included describing some pumping stations of the Metropolitan Water Board and one at Bristol. An example of control in terms of differential pressure is given by a booster station on the Cambridge system. In an existing station, re-arranged to supply an additional district, the differential pressure between the mains leading to the old and new areas controls the speed of the induction-regulated motors driving the pumps. The Chew Stoke station on the Bristol system is an example of control by water level. Four pump units in the station are automatically started or stopped in accordance with the water level in a tank at Stowey some miles distant. In addition to the usual overload and no voltage protection, a safety trip is provided which will stop the pumps in case of a burst main.



The Empress of England leaving the slipway at Vickers Naval Yard on May 9. (See note " Land, Sea and Air.")

Industrial Safety Training

The standard of safety precautions in British industry is high, and to-day few industrial accidents are attributable to contravention of the statutory safety regulations. It is, nevertheless, impossible to legislate all risk out of the factory; and in order to avoid preventable accidents propaganda and training are necessary. As regards industrial accident rates, the highly industrialised Birmingham area compares well with other parts of England. This is largely due to the efforts of the Birmingham and District Industrial Safety Group, who five years ago started an industrial training centre, the first of its kind in the United Kingdom.

They have now moved the training centre to a new headquarters in Summer-road, Acocks Green, Birmingham, which was officially opened by the Minister of Labour and National Service recently. In conjunction with the opening of the new centre, the Group held a one-day conference at which the way the new training centre will endeavour to reduce industrial accidents was outlined, and a film for training young people was shown.

To ensure that safe methods of working and handling materials and equipment are properly taught and practised on the shop floor, the first essential is to ensure that the supervisory grades —from charge-hands to works superintendent— appreciate the risks inherent in the various processes and the way to guard against them. Accordingly two-day courses will be held for supervisors covering such subjects as the Factory Acts requirements, the fencing of machinery, plant installation, fire escape, removal of dust and fumes, common types of accident, and so on. Thus the supervisors will learn in order to teach their workers to look after their own safety. There will also be courses for works electricians; for crane drivers and operators of lifting gear, truck drivers, millwrights and toolsetters.

In addition, the Birmingham and District Industrial Safety Group place great emphasis on the necessity for bearing safety considerations in mind right from the start of the design of a product and through its tooling stages; and of the importance of managements keeping up to date in their knowledge of means for preventing accidents. They intend, therefore, to stage frequent demonstrations of particular aspects of safety that are often ignored, and to publicise as widely as possible all relevant information.

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Regent's New Refinery

It was announced last week that the Regent Oil Company Limited, which is jointly owned by the California Texas Corporation and the Trinidad Oil Company, Limited, is to build its first refinery in this country, beginning this year. The annual throughput is to be 5 million tons a year which, by coincidence, is the short fall for coal output in this country scheduled for 1965 in the new coal plan announced recently, compared with the old one. The cynics may well comment that the optimistic estimates of the old plan were a brave but costly exercise at £25 million—this is the sum which the Regent refinery is expected to cost. Plans for expansion for the refinery, which is likely to be built at Southampton, are being worked into the planning of the site.

Since December, 1955, the oil industry has announced development plans amounting to £40 million. It has been calculated recently that by 1980, the inland consumption of oil products in this country will be about 90 million tons a year. In 1955, inland consumption totalled 19 million tons, and even allowing for the fact that refinery capacity in this country was not fully used, and for the substantial trade in imported refined oil products, there is tremendous scope for a refinery expansion programme in the next few years. The problem for the future is less one of expansion of total capacity than of estimating the correct fractions to take from the crude oil. The demand for

Diesel oil and fuel oils is increasing while the future of the demand for petrol is, at least temporarily, somewhat obscured by the Government's deflationary policy. For the time being, too, the black oils are favoured by the heavy taxation on petrol, but taxation policy can be notoriously opportunist. These are some of the complications which the oil industry faces in raising its capacity quickly and on a large scale over the next decade. The recent controversy over the tied garage and the importance which the large companies attach to ensure an outlet for petrol through secured channels, shows how sensitive they are about the market for their products in spite of the excellent long-term output.

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Sales Curves for Cars

The creation of graceful automobile body styles has become big business in Italy, earning large sums in foreign currency. It has established the Italians as the arbiters of automobile style, and it is not surprising to hear that British manufacturers are calling Italian experts into consultation to profit from their experience in evolving body lines that sell. In the United States, Nash has made great use of Pinin Farina, while Chrysler and Ford have bought many experimental body styles from Ghia. Hundreds of M.G's and Bristols have been sold with Bertone bodies built for an American agent, and Bertone hopes to repeat the success with the Aston Martin convertible which was exhibited at the Turin Show.

Carrozzeria Touring are establishing a subsidiary in Madrid to build bodies for Pegaso. France's Peugot 403 saloon was styled by Farina, and even Volkswagen went to Ghia for the design of their elegant new two-seater coupe, which is now selling well at nearly twice the price of the standard saloon.

The Italian method in creating new body designs is a simple one, based on a long tradition of expert craftsmanship in metal work. The designer works closely with his team of sheet-metal workers, using nothing more than a few perspective sketches, or a wooden panel horse in skeleton form to establish the main lines. The final shape evolves and is modified as the work proceeds. Leading Italian stylists have tried modelling in clay but have rejected it as too slow and laborious. One of them, who has worked in the styling studios of one of the biggest American manufacturers, says he can get an experimental body built and running on the road in Turin in less time than it would take to finalise a clay mock-up in Detroit. Carrozzeria Touring built a superb convertible body on an Aston Martin chassis in only 17 days before the Turin Show. Pinin Farina, having prepared sketches and a wooden panel rig for a body on a new Alfa Romeo received a chassis which was 10 inches shorter than expected. They started again with only 23 days to go, and completed the body by the Show's opening day. Hence the lack of interest on the part of the Italian industry in other short cuts, such as construction in glass-reinforced plastics which are finding favour elsewhere. Plastics are, however, finding a place on commercial vehicles, and one Italian coach-builder showed a 48 seater motor coach at the Turin Show, which had a body constructed entirely of plastics on a steel-tube sub-frame.

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Capital Outlay in 1955

Figures of the actual capital expenditure during the last quarter of 1955, have now been published by the Board of Trade. It will be recalled that preliminary estimates of changes in fixed capital expenditure by private industry were published earlier this year by the Board under the voluntary inquiry which the Government has now instituted on a regular basis with private concerns. The statistics now released show that manufacturing industry increased its outlay on fixed capital assets by 27 per cent. in 1955, compared with 1954. This represents an increase of 48 per cent. in building work and of 21 per cent. in plant, machinery and vehicles.

The largest increase (and it was particularly marked in building activity) was the 95 per cent. increase in motor vehicles. Vehicles as a whole raised their expenditure by 75 per cent., and they were followed at some distance by the paper and printing industries with an increase of 50 per cent. The smallest increases in manufacturing industry were recorded by chemicals and metal manufacture, the latter including iron and steel. Chemicals went up by 13 per cent., as did metal manufacture, both being exceeded by textiles and clothing with an increase of 16 per cent. The figures for shipping, which relate mainly to the purchase of new tonnage, showed an increase of only 6 per cent. on the year. Other industries, which include building and constructing work, transport other than shipping and the distributive trades increased their capital expenditure last year by 31 per cent.

Significant changes are likely to be recorded in 1956. The Government look forward to an increase in capital investment this year and whatever may be the total figure by next December, shipping and chemicals—and possibly iron and steel as well—are likely to show comparatively larger increases. The impact of the large number of shipbuilding orders last year will be felt on the yards in 1956 and the increased oil refinery programme is also likely to affect the figures. By contrast, vehicles are not likely to do more than maintain their present high rate of expenditure.

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Land, Sea and Air

The Vickers group is one of the largest and most diversified engineering concerns in the country, and its wide range of capital equipment (from ships to punched-card tabulators) has so far been immune from the consequences of the credit squeeze. Net profits of the group after taxation rose by nearly 70 per cent., from £3·3 million in 1954 to a record of £5·6 million in 1955. The prosperity of the company shows no appreciable sign of slackening in the new financial year.

The greatest publicity has, of course, been given to the success of the Viscount, and pride of place is justifiably given to it in the chairman's review of the year. Sales of Viscounts are now well past the 300 mark. In the dollar market Trans-Canada Air Lines testify to the immediate popularity of the Viscount with North American passengers, and they attribute a large proportion of their expanded traffic to it. It remains to be seen how the new Vanguard will make out as the Viscount's successor. Meanwhile, in the field of military aircraft, it is expected that the first squadron of Swifts will soon be in operation, and further trials on guided missiles are said to be progressing satisfactorily.

The Vickers group also shared the prosperity of the shipbuilding industry last year. Gross tonnage launched was up by 30 per cent., while orders for 13 additional ships were placed totalling 190,000 gross tons. The launching of the then largest tanker in the world brought the total tonnage built since the war up to a million tons gross. While the large amount of tanker work was the main source of the group's shipbuilding success, passenger ships were also important. The Empress of England, launched by Lady Eden last week, is the largest passenger ship to be built at the company's Naval Yard at Newcastle-upon-Tyne. She is a sister ship to the Empress of Britain, already in service with Canadian Pacific.

The Metropolitan-Cammell Carriage and Wagon Company, Limited—to single out, however invidiously, one of Vickers many general engineering interests—continued to prosper against intensifying overseas competition and despite shortages of steel and rising costs at home. While production figures received a slight setback owing to material shortages, among important orders received were one for 349 coaches from South Africa and another for 2,000 wagons for India. Meanwhile the company stands to benefit from modernisation plans at home, and deliveries of Diesel railcars for British Railways were begun last year. All in all, the recent Vickers record of expansion, reorganisation and prosperity is a seemly valediction for Sir Ronald Weeks, who has signified his intention to retire from the chairmanship.

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Ships in the Doldrums

Even in the these days of buoyant international trade and a steady flow of shipbuilding orders, those who make or operate ships have their preoccupations. Cammell Laird and Company, Limited, whose accounts have just been published, show consolidated trading profits for the year ended December 31, 1955, nearly 8 per cent. higher than for 1954. All things considered, this was a good year for the company, but the much publicised strike in the shipbuilding yards at Birkenhead probably prevented it from being an outstanding one. The demarcation strike which began last September and continued off and on until March, affected the fitting out and completion of six ships, which delayed the launching of two more and held up the laying down of two new keels.

Much has been heard in the last few weeks of the threat to British shipping of the increasing world tonnage sailing under "flags of convenience." Sir William Currie, chairman and managing director of Peninsular and Oriental Steam Navigation Company, had a good deal to say on this subject last week in his annual statement. Sir William emphasised that when the next shipping slump occurs those companies which bear their national responsibilities on taxation and social services will find it difficult to compete on price. "Flags of convenience" now rank third to the U.K. and the U.S. among the world tanker tonnage and are becoming increasingly important in dry cargo as well. It is clear that Sir William does not himself lean towards adapting a "flag of convenience" policy, partly for reasons connected with British shipping tradition and partly because there is no taxation advantage in setting up a foreign subsidiary for registration purposes. The possibility of setting up a subsidiary company within the Commonwealth is not mentioned in the speech—an omission which might prove significant.

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Rolls-Royce Conways for Canada

The announcement by Trans-Canada Air Lines that they have ordered four Douglas DC-8 air-liners, with an option on two more, to be powered by Rolls-Royce Conway by-pass turbo-jets, is perhaps the happiest piece of British aeronautical news since Capital Air Lines ordered Vickers Viscounts. The first four aircraft are to be delivered in 1960, and the other two—if the order is confirmed—will follow a year later.

The Conway will be the first British turbo-jet to power an American air-liner. It has been selected by Trans-Canada in preference to the Pratt and Whitney J.75 turbo-jet as the power plant for their DC-8 aircraft because (1) it has a lower first cost; (2) is lighter in weight and therefore offers the prospect of 300-400 miles additional range, or a higher payload; (3) on the transatlantic route for which these aircraft are destined, the Conway installation promises a slightly lower operating cost; and (4) 15 years of close contact between Trans-Canada Air Lines and Rolls-Royce Limited, and the satisfaction they have obtained from the Merlin and Dart engines, have bred confidence in Rolls-Royce products. This, in fact, must be considered a decisive factor when it is remembered that the Conway has no service experience.

In order to provide the necessary background of flying hours, the British Government have promised their support. The Conway will be ordered for installation in a four-engine bomber —as yet unspecified. Without such operational experience, Rolls-Royce would not be prepared to supply Conways to the Douglas company.

It is expected both by Rolls-Royce Limited and by the Douglas Aircraft Company Incorporated that other prospective DC-8 customers will follow the lead set by Trans-Canada and specify Conway engines.

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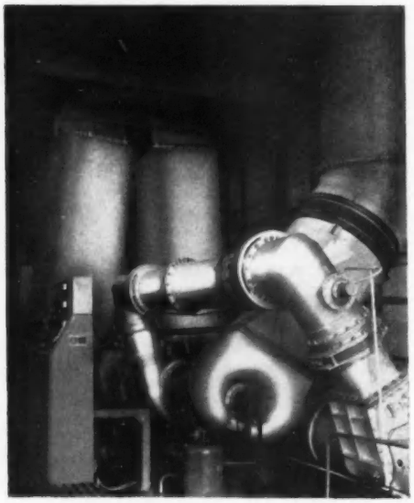
Bristol Turbo-jet

Bristol Aero-Engines Limited also hope to enter the American commercial aircraft market with their Olympus turbo-jet, and have recently been discussing with the Boeing Airplane Company its possibilities for both the domestic and inter-continental versions of the Boeing 707 air-liner. So far, no definite agreements have been announced.

The Boeing Company are themselves interested in the Conway. The developed performances of the three rival engines—the Olympus, the Conway and the Pratt and Whitney J.75—are all shrouded by security restrictions, but it is understood that they will be closely competitive. The Bristol Company claim that the Olympus has the advantage over the other two in specific fuel consumption. Bristol, however, are likely to be at some disadvantage in the commercial market because, as yet, they have no real operational background with turbine engines, either jets or turbo-props, although they have accumulated many development flying hours on both Olympus and Proteus engines. That such development flying is not necessarily sufficient to reveal all possible snags has been shown by the recent experience of B.O.A.C. in route-proving trials with the Britannia over the South African route in heavy cloud, during which momentary engine cuts have occurred due to the accretion of water or ice in one or more combustion chambers.



Ruston and Hornsby gas turbine installed in the Admiralty test house, Pyestock, for heavy fuel combustion chamber research.

The Bristol Company state that modifications to the Proteus air-intake and combustion chambers, and an automatic relighting system, which are expected to overcome the trouble, should be incorporated by the end of the month; and that there is still a reasonable prospect that B.O.A.C. will be able to adhere to their plan for putting Britannias into commercial operation this summer.

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Making Best Use of Gas Turbines

Once upon a time many people thought that gas turbines would soon replace reciprocating engines as prime movers in all but the most exceptional cases. This may still prove to be true, but meanwhile it is important to find those applications and circumstances in which the gas turbine can already show an advantage. By developing a robust and flexible unit, the TA 750 to 1,000 kW turbine, Ruston and Hornsby, Limited, of Lincoln have made best use of this opportunity.

At a recent Press conference, Mr. G. B. R. Feilden, the company's engineering director, said that during the marketing of an engine, it was often found that the purposes for which it had originally been conceived were superseded by other applications not previously foreseen. This has been especially true of the Ruston engine, which has proved unexpectedly to be in particular demand for installations requiring both power and process heat. He also observed that the gas turbine was complementary to the Diesel engine rather than a competitor, and could perform tasks which before would not have been attempted. The gas turbine was a weak-mixture machine; the dew point of the exhaust gas was lower than in a boiler or internal-combustion engine, and the exhaust still contained some oxygen; this could be used in an afterburner to provide heat for boilers or other processes. On simple thermal efficiency the Diesel engine held the lead, but the Ruston turbine with exhaust heat recovery used in conjunction with an Economic boiler could attain efficiencies of 70 per cent. by use of the exhaust gases directly and 79 per cent. with reheat, which were unsurpassed.

What characteristics help to make the Ruston turbine so adaptable? Primarily, it is its capacity to burn a wide range of fuels: methane in natural or sewage gas, peat, coal-tar, gas-oil and later perhaps the heavier grades of oil; the accompanying illustration shows a unit for heavy-fuel combustion chamber research in the Admiralty test house at Pyestock, Hampshire. It might also use the heat from a nuclear reactor, directly without heat exchangers, by means of the closed-cycle helium system; little alteration to the basic unit would be necessary, though the compressor compression ratio would fall from 4 : 1 to 2 :1. Another contribution to versatility is the method of fixing inlet and outlet ducting which can be rotated on the flanges to point in various directions, thus simplifying installation; the unusual position of the ducts in the Pyestock plant can be seen from the illustration. Other features of the engine are the use of kinematic construction to permit differential expansion on heating up; a comprehensive air cooling system bled from half-way along the compressor; and an elbow combustion chamber, which is a simple and convenient means of directing the air flow to the burner without creating sufficient draught to blow the flame from the nozzle.

It is not surprising that the turbine is in demand. Thirty-six engines have been ordered, the latest by the Admiralty, with 13 already installed or in transit; 17 are for export and 18 will be equipped with waste-heat recuperation. Each engine is fully tested before it leaves the factory and a test house has recently been built for this purpose, together with a propane plant. This will supply gas, diluted with air to give a calorific value corresponding to that of the various gases on which engines will operate. We hope to describe the two new installations in a subsequent issue. It may be of interest that the prototype turbine, the 750 kW 3CT engine, which first ran in 1949, is still in operation and is used extensively for testing.

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Setting a Standard

In technical education as in any other field it is necessary to decide exactly what is wanted before steps can be taken to carry it out. The Government have therefore been wise to create the National Council for Technological Awards as a prelude to their plans for increasing the number of technologists in this country. The Council has been set up as an independent self-governing body to establish and administer technological awards of high standing having a national currency and available to students in technical colleges who successfully complete courses approved by the Council. To achieve this aim it is required to formulate standards for the courses which will lead to the award, the Diploma of Technology; this will be denoted by "Dip.Tech.(Eng.)" for engineering, and simply "Dip.Tech." for other technologies.

In announcing publication of the Council's "Memorandum on the Recognition of Courses in Technical Colleges leading to the Diploma in Technology," which gives details of the award, the courses and conditions for admission, Lord Hives, first chairman of the Council, said that there would be two honours classes, first and second, and that students successfully completing the course would normally reach the level of second class honours; others would be considered for award of the Diploma at pass level. Though of comparable standing to university courses, the Diploma course would be more closely related to industrial training, but would be more broadly based than Higher National Courses. The period required for academic studies in a technical college would not be less than three years full-time or four years sandwich, but in any case the total requirement would be not less than four years including at least one year in industry. The minimum age for admission would be 18. These were, however, the bare bones of the scheme and, as Sir Harold Roxbee Cox observed on the same occasion, the Council would have to depend on "case law" for future developments.

Lord Hives was optimistic about the response to these proposals; already, he said, applications had been received from colleges and some courses had already been started. However, though it is not the task of the council to decide how the standards set are to be attained, it is necessary to be realistic and it is difficult to see at present where staff of adequate calibre and in sufficient numbers, and accommodation, are to be found. Moreover, it is important that the senior engineering institutions support the plan; although they are represented on the Council, they cannot as yet commit themselves to accepting the Dip. Tech.(Eng.) as qualification for membership. Nevertheless, the work of the Council must in the long run prove useful, for standards of some kind are essential. In his Presidential Address to the Association of Teachers in Technical Institutions, Mr. A. K. Brown said: "By setting and maintaining high standards the Council can ensure that this new award will be accepted as a valuable and desirable qualification for the technologist, equal to and superior in usefulness to a university degree."

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Mr. Frank Perkins, chairman and managing director of F. Perkins Limited, and one of last year's vice-presidents of the Society of Motor Manufacturers and Traders, has been elected President of the Society for the ensuing twelve months, in succession to Dr. F. Llewellyn Smith, managing director of the motor car division of Rolls-Royce, Limited. Born on February 26, 1889, Mr. Perkins was educated at Rugby School, and at Cambridge University where he took a degree in engineering. He formed his own firm, F. Perkins Limited, at Peterborough in 1932, to manufacture high-speed Diesel engines from his patents. He foresaw the world-wide demand for Diesel engines which would arise in the present post-war period and, with the completion of a new factory at Peterborough in 1947, his company has developed into one of the leading manufacturers of lightweight Diesels.

Mr. A. M. Holbein is resigning as managing director of D. & C. and William Press Limited, in order to be able to devote sufficient time to the work of the Federation of Civil Engineering Contractors, of which he has been elected President. He will, however, continue as an active director of the company and of Demolition and Construction Limited. The new managing director of D. & C. and William Press will be Mr. Andrew Morrison, M.I.Mech.E., who joined the firm in 1952, and who was previously general manager of the Anglo-Iranian Oil Company, Limited, in Abadan.

CALCULATING GAS-TURBINE PERFORMANCE

RAPID METHOD FOR FINDING CONDITIONS OF OPTIMUM EFFICIENCY

By W. R. Hawthorne, M.A., SC.D.* *and G. de V. Davis*, B.E.†

A method is described for estimating the performance of gas-turbine cycles with varying degrees of intercooling, reheating and regeneration. For given temperatures and component efficiencies it is shown that the pressure ratios for optimum efficiency and work, and the values of optimum efficiency, etc., can be rapidly determined by a graphical method. Some examples illustrating results obtained with the method are included.

METHOD OF ANALYSIS

The calculation of the performance of gas turbines is a straightforward process once the efficiencies of the components can be estimated. There are, however, many instances in which comparisons are required of cycles with differing arrangements, pressure ratios and component efficiencies, etc. For these comparisons approximate methods may often suffice, and the use of graphical procedures may be justifiable. This is particularly the case when, with other conditions fixed, the pressure ratio for maximum efficiency is to be determined.

The calculation of the thermodynamic performance of a gas turbine depends on a knowledge of the magnitude of the efficiencies and irreversibilities in the actual processes. These are estimated from experience, guided by detailed knowledge of the processes in the various components. With the help of enough of this knowledge, and the results of tests of the actual components and tables of the properties of the working fluids, calculations of the performance can be made to any desired degree of accuracy. To explore the behaviour of various types of gas-turbine plants, less detailed analysis is often sufficient, and the assumption of constant specific heats over the whole or parts of the process is often adequate.

To illustrate the development of the method some simple cycles will be treated, assuming that the specific heats are constant and that the increase in mass flow due to addition of the fuel in the combustion chamber can be neglected. Each analysis will, however, be introduced in such a manner that accurate tables of properties may be used. Losses in ducting, heat exchangers and combustion chambers will be neglected, although later they will be allowed for by a method justified in an Appendix.

For actual gas turbines, since the processes are irreversible and generally not cyclic (except in the closed-cycle arrangements), the temperature-entropy diagram is of little value, and the processes are best represented on the enthalpy-entropy diagram.

* Professor of Applied Thermodynamics, University of Cambridge.

† Research Student, Department of Engineering, Cambridge.

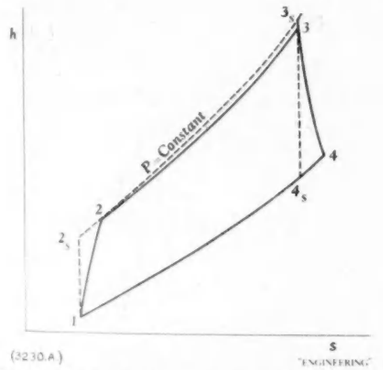


Fig. 1 Enthalpy-entropy diagram for a simple gas-turbine plant—(CBT).

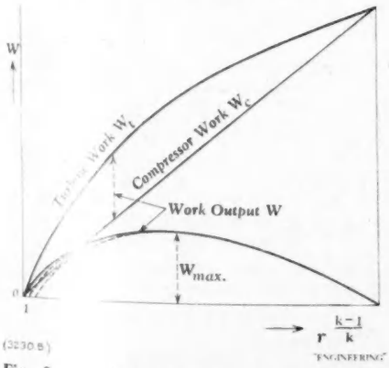


Fig. 2 ...rtion of compressor and turbine with $r^{\frac{k-1}{k}}$ for (CBT) plant.

Nomenclature

(B) indicates the presence of a combustion chamber in the gas-turbine plant, (C) a compressor, (I) an intercooler, (T) a turbine and (X) a regenerator.

C_p	=	specific heat at constant pressure,
C_f	=	specific heat of fuel,
f	=	ratio (fuel mass flow/air mass flow),
h	=	enthalpy,
k	=	ratio of specific heats at constant pressure and constant volume,
m	=	number of intercoolers present plus one,
n	=	number of reheaters present plus one,
p	=	pressure,
Δp	=	pressure loss,
q	=	enthalpy change,
r	=	pressure ratio,
s	=	entropy,
T	=	absolute temperature,
W	=	work done or produced,
η	=	efficiency.

Subscripts

1, 2, ... 8, a, b, m, n	points on a gas turbine cycle.
c	compressor.
f	fuel.
m or max.	maximum.
s	isentropic conditions.
T	at temperature T.
t	turbine.
x	regenerator.

SIMPLE GAS TURBINE

The processes in a simple gas-turbine plant comprising compressor (C), combustion chamber (B) and turbine (T), are shown on an enthalpy-entropy (h-s) diagram, Fig. 1.

Compression occurs from 1 to 2 with an efficiency η_c defined as

$$\eta_c = \frac{h_{2s} - h_1}{h_2 - h_1} \quad . \quad . \quad (1)$$

Combustion at slightly decreasing pressure occurs from 2 to 3, and expansion from 3 to 4 with an efficiency η_t defined as

$$\eta_t = \frac{h_3 - h_4}{h_3 - h_{4s}} \quad . \quad . \quad (2)$$

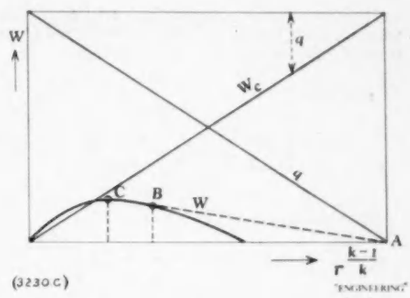


Fig. 3. Values of q plotted against $r^{\frac{k-1}{k}}$ for (CBT) plant.

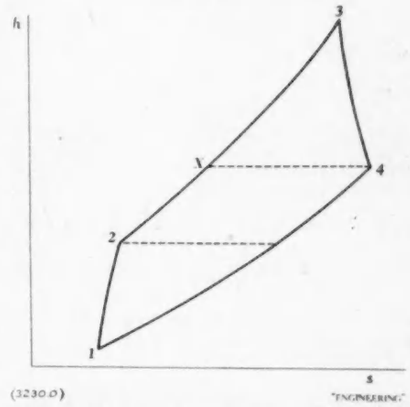


Fig. 4 Enthalpy-entropy diagram for (CBTX) gas-turbine plant with a regenerator of unit effectiveness.

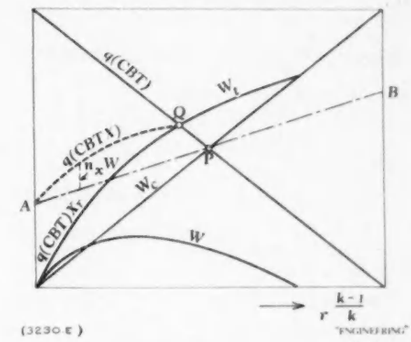


Fig. 5 Values of q plotted against $r^{\frac{k-1}{k}}$ for three types of plant.

The work done in the compressor per lb., $W_c = h_2 - h_1$. The work done in the turbine per lb., $W_t = h_3 - h_4$. The net work output $= (1 + f)(h_3 - h_4) - (h_2 - h_1)$ where f is the ratio of mass flow of fuel to that of air.

Assuming no heat losses and perfect combustion, the enthalpy balance in the combustion chamber gives :

$$(1 + f)(h_3 - h_T) = (h_2 - h_T) + f\,[C_f(T_f - T) - h_{rp}] \quad (3)$$

where h_{rp} is the enthalpy of combustion per pound of fuel at temperature T and pressure p_2, T_f is the temperature of the fuel, and C_f is its specific heat.

Hence :

$$h_3 - h_2 = \frac{f}{1 + f}\,[C_f(T_f - T) - h_{rp} - (h_2 - h_T)] \quad . \quad . \quad . \quad (4)$$

and approximately,

$h_3 - h_2 = -f h_{rp} = f$ (heating value of fuel per lb. at constant pressure) $= q$ (5)

If the assumptions of constant specific heats,

no pressure loss in combustion, and negligible value of f are made, the work done in the compressor becomes :

$$W_c = \frac{1}{\eta_c}(h_{2s} - h_1) = \frac{C_p T_1}{\eta_c}\left[\left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} - 1\right] = \frac{C_p T_1}{\eta_c}\left[r^{\frac{k-1}{k}} - 1\right] \quad . \quad . \quad . \quad (6)$$

The work done in the turbine

$$W_t = \eta_t (h_3 - h_{4s}) = \eta_t C_p T_3 \left[1 - \left(\frac{1}{r}\right)^{\frac{k-1}{k}}\right] \quad . \quad . \quad . \quad . \quad (7)$$

whence

$$\frac{\text{turbine work}}{\text{compressor work}} = \eta_c \eta_t \frac{T_3}{T_1}\left(\frac{1}{r}\right)^{\frac{k-1}{k}} \quad (8)$$

where $r = \frac{p_2}{p_1} = \frac{p_3}{p_4}$.

Typical curves of the variation of compressor and turbine work with $r^{\frac{k-1}{k}}$ are shown in Fig. 2. The difference between turbine work and compressor work is the work available for driving the load. This is also shown in Fig. 2. It is zero when $r = 1$ and $r^{\frac{k-1}{k}} = \eta_c \eta_t \left(\frac{T_3}{T_1}\right)$. Hence unless $\eta_c \eta_t \left(\frac{T_3}{T_1}\right)$ is equal to or greater than $r^{\frac{k-1}{k}}$ the plant will not operate or deliver useful work.

The useful work output

$$W = \frac{C_p T_1}{\eta_c} \frac{r^{\frac{k-1}{k}} - 1}{r^{\frac{k-1}{k}}} \left[\eta_t \eta_c \left(\frac{T_3}{T_1}\right) - r^{\frac{k-1}{k}}\right]. \quad (9)$$

When T_3, the temperature at inlet to the turbine, and T_1, the temperature at inlet to the compressor are fixed, this may be differentiated with respect to $r^{\frac{k-1}{k}}$ and the differential put equal to zero to find the maximum work output, which occurs when

$$r^{\frac{k-1}{k}} = \sqrt{\eta_t \eta_c \frac{T_3}{T_1}} \quad . \quad . \quad (10)$$

and is equal to

$$W_{max.} = \frac{C_p T_1}{\eta_c}\left[\sqrt{\eta_t \eta_c \frac{T_3}{T_1}} - 1\right]^2. \quad (11)$$

In this simple analysis η_t and η_c are assumed to be independent of the pressure ratio. When ducting and combustion-chamber losses are allowed for by reducing the turbine efficiency, this is no longer true especially at low pressure ratios. Consequently, at low pressure ratios the turbine and useful work output will be reduced and will reach zero at a pressure ratio greater than unity, as indicated by the broken lines in Fig. 2. Continuing with the analysis on the assumption that the ducting and compressor pressure losses may be neglected, and with the object of finding the pressure ratio for maximum efficiency for fixed T_3 and T_1 :—

The value of $q = h_3 - h_2 = C_p (T_3 - T_2)$
$= C_p (T_3 - T_1) - W_c$. . (12)

The value of q is shown plotted against $r^{\frac{k-1}{k}}$ in Fig. 3.

When $r = 1$, $q = C_p (T_3 - T_1)$; and $q = 0$ when

$$C_p (T_3 - T_1) = W_c = \frac{C_p T_1}{\eta_c}(r^{\frac{k-1}{k}} - 1) \quad (13)$$

or when

$$r^{\frac{k-1}{k}} = (1 - \eta_c) + \eta_c \frac{T_3}{T_1}. \quad (14)$$

This point is shown as A on Fig. 3.

A straight line through A may be drawn intersecting the curve for W in two points for which $\frac{W}{q}$ has the same value. The maximum value of efficiency $\frac{W_{max.}}{q}$ is given by the line through A drawn tangent to the curve for W at the point B. From Fig. 3 the value of the pressure ratio corresponding to B, the point of maximum efficiency, is larger than the value of the pressure ratio at maximum work, point C.

Now the efficiency

$$= \frac{W}{q} = \frac{W_t - W_c}{C_p (T_3 - T_1) - W_c} \quad (15)$$

and

$$(1 - \eta) = \frac{C_p (T_3 - T_1) - W_t}{C_p (T_3 - T_1) - W_c} \quad . \quad (16)$$

The maximum efficiency occurs when the differential of this expression with respect to (pressure ratio) $^{\frac{k-1}{k}}$ is zero; i.e. when

$$[C_p (T_3 - T_1) - W_t] \frac{dW_c}{d\left(r^{\frac{k-1}{k}}\right)} = [C_p (T_3 - T_1) - W_c] \frac{dW_t}{d\left(r^{\frac{k-1}{k}}\right)} \quad (17)$$

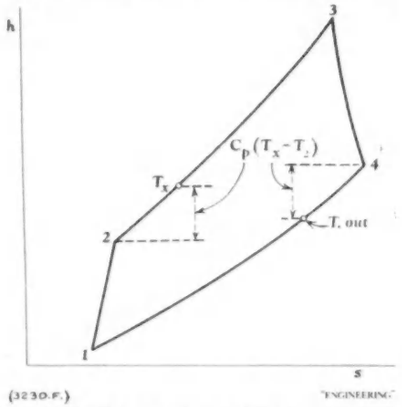


Fig. 6 Enthalpy-entropy diagram for gas-turbine plant with a regenerator of effectiveness less than unity.

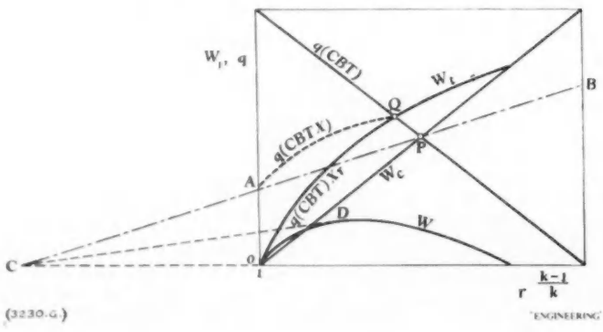


Fig. 7 Construction to find maximum efficiency for (CBTX) plant.

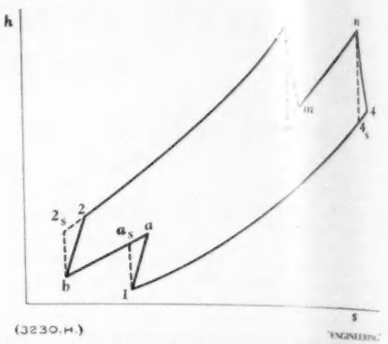


Fig. 8 Enthalpy-entropy diagram for gas-turbine plant with intercooling, reheat and heat exchange —(CICBTBTX).

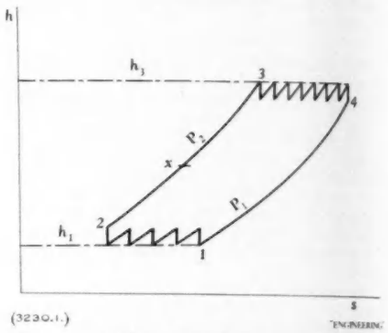


Fig. 9 Enthalpy-entropy diagram for several stages of intercooling and reheating and a regenerator.

or when

$$[C_p (T_3 - T_1) - W_t] r^{\frac{k-1}{k}} - [C_p (T_3 - T_1) - W_c] \eta_c \eta_t \frac{T_3}{T_1} \times \frac{1}{r^{\frac{k-1}{k}}} = 0 \quad . \quad . \quad . \quad (18)$$

which on substitution and simplification gives

$$\frac{\left(r^{\frac{k-1}{k}}\right)^2}{\eta_t \eta_c \frac{T_3}{T_1}} - \frac{\left(r^{\frac{k-1}{k}} - 1\right)^2}{\eta_c \left(\frac{T_3}{T_1} - 1\right)} = 1. \quad (19)$$

The algebraic solution of this is given by

$$r_m^{\frac{k-1}{k}} = \frac{\eta_t \frac{T_3}{T_1}}{1 - (1 - \eta_t)\frac{T_3}{T_1}} \times \left\{1 \pm \sqrt{\frac{\left(\frac{T_3}{T_1} - 1\right)}{\eta_t \frac{T_3}{T_1}}\left[\eta_c \left(\frac{T_3}{T_1} - 1\right) + 1 - \eta_t \eta_c \frac{T_3}{T_1}\right]}\right\} \quad . \quad . \quad . \quad (20)$$

where r_m is the value of the pressure ratio at maximum efficiency, and the maximum efficiency η_m is given by

$$1 - \eta_m = \frac{\eta_c \eta_t \frac{T_3}{T_1}}{\left(r_m^{\frac{k-1}{k}}\right)^2}. \quad . \quad (21)$$

GAS TURBINES WITH REGENERATORS

Heat exchanger performance is defined in terms of an effectiveness η_x, where

$$\eta_x = \frac{\text{Temperature rise of cold stream}}{\text{Temperature difference between hot and cold stream at inlet.}}$$

An interesting example is obtained by combining the simple (CBT) plant described above

with a regenerator X_r, the effectiveness of which equals unity. For constant specific heat, this gives the enthalpy-entropy diagram shown in Fig. 4, in which the point x shows the state of the air as it passes from the regenerator to the combustion chamber. The work output is the same as for the (CBT) plant but the value of q is now equal to the work done in the turbine.

Hence the efficiency is

$$\eta = \frac{W_t - W_c}{W_t} = 1 - \frac{r^{\frac{k-1}{k}}}{\eta_t \eta_c \frac{T_3}{T_1}} \quad (22)$$

and is a maximum when pressure ratio $r = 1$.

No regenerator can be used when $T_2 > T_4$; i.e., when q for (CBT) X_r is equal to that for (CBT). This point of intersection, Q, of the curves for q is shown in Fig. 5. Note that this always occurs at a pressure less than that for the point of intersection of q for (CBT) and W_c.

Fig. 6 shows the h-s diagram for a gas turbine with a regenerator of effectiveness less than unity.

$$q = C_p (T_3 - T_x) = C_p (T_3 - T_4) + C_p (T_4 - T_x) \quad (23)$$

Now

$$\eta_x = \frac{T_x - T_2}{T_4 - T_2} \quad . \quad . \quad (24)$$

and

$$1 - \eta_x = \frac{T_4 - T_x}{T_4 - T_2} \quad . \quad (25)$$

whence

$$q = W_t + (1 - \eta_x) C_p [T_3 - T_2 - (T_3 - T_4)] = \eta_x W_t + (1 - \eta_x) C_p (T_3 - T_2) \quad (26)$$

The curves in Fig. 5 show the relation between the values of q for the three different plants. Note that all curves for q (CBTX) pass through the point Q.

Equation (26) for q (CBTX) may also be written

$$q\,(\text{CBTX}) = \eta_x W + [\eta_x W_c + (1 - \eta_x) \times \{C_p (T_3 - T_1) - W_c\}] \quad (27)$$

The term in the square brackets is linear in $r^{\frac{k-1}{k}}$ and may be represented by the line AB in Fig. 5.* By symmetry this passes through P. The curve for q (CBTX) is constructed by adding $\eta_x W$ to the ordinate of this line.

Now

$$\frac{1}{\eta\,(\text{CBTX})} = \eta_x + \frac{\eta_x W_c + (1 - \eta_x) [C_p (T_3 - T_1) - W_c]}{W} \quad . \quad . \quad . \quad (28)$$

The efficiency of (CBTX) becomes a maximum when

$$\frac{W}{\eta_x W_c + (1 - \eta_x) [C_p (T_3 - T_1) - W_c]}$$

is a maximum.

The point of maximum value of the efficiency may be found by a geometric construction similar to that used to find the maximum for η (CBT). In Fig. 7, AB is extended to cut the horizontal axis in C and the tangent CD is drawn to the curve for W. D is then the point of maximum efficiency. When the regenerator effectiveness $\eta_x = 0{\cdot}5$, the line AB is horizontal and the point of maximum efficiency of (CBTX) and the point of maximum work occur at the same pressure ratio. The pressure ratio for maximum efficiency of (CBTX) is always less than the pressure ratio for maximum efficiency of (CBT).

GAS TURBINE WITH INTERCOOLING, REHEAT AND REGENERATOR (CICBTBTX)

The enthalpy-entropy diagram for a plant with intercooling, reheat and heat exchange is shown in Fig. 8. It will be assumed that each turbine has the same efficiency, η_t. A similar assumption will be made for the compressors.

* Note that the ordinate at A equals $(1 - \eta_x) C_p (T_3 - T_1)$, and that at B, where $W_c = C_p (T_3 - T_1)$, is given by $\eta_x C_p (T_3 - T_1)$.

TABLE I

Calculations of W_c and W for T_3 = 1,200 deg. F.; T_1 = 68 deg. F., $m = 4$, $n = 2$, $\eta_c = 0{\cdot}87$, $\eta_t = 0{\cdot}91$, $\Sigma \frac{\Delta p}{p} = 0{\cdot}148$

r	5	10	15	20	25	30
$\sqrt[4]{r}$	1·496	1·778	1·968	2·115	2·236	2·338
h_1	126·18	126·18	126·18	126·18	126·18	126·18
p_{r_1}*	1·2813	1·2813	1·2813	1·2813	1·2813	1·2813
p_{r_2}*	1·9168	2·2781	2·5216	2·7099	2·8650	2·9957
h_{t_3}	141·62	148·83	153·21	156·25	158·94	160·98
$\frac{W_c}{4}$	17·75	26·03	31·07	34·56	37·66	40·00
r_t	4·26	8·52	12·78	17·04	21·30	25·56
$\sqrt{r_t}$	2·064	2·919	3·575	4·129	4·615	5·056
h_3	411·82	411·82	411·82	411·82	411·82	411·82
p_{r_3}*	82·83	82·83	82·83	82·83	82·83	82·83
p_{r_4}*	40·131	28·376	23·169	20·061	17·948	16·383
h_{t_5}	336·59	305·37	288·39	276·87	268·50	261·44
$\frac{W_t}{2}$	68·46	96·87	112·32	122·80	130·42	136·85
$\frac{W_c}{2}$	35·50	52·06	62·14	69·12	75·32	80·00
$\frac{W}{2}$	32·96	44·81	50·18	53·68	55·10	56·85

* These symbols correspond to those used in reference (10) to determine the pressure changes occurring in an isentropic process.

TABLE II.—CONDITIONS AT OPTIMUM EFFICIENCY.

T_3 = 1,200 deg. F.; T_1 = 68 deg. F.; $m = 4$; $n = 2$; $\eta_c = 0{\cdot}87$; $\eta_t = 0{\cdot}91$; $\Sigma \frac{\Delta p}{p} = 0{\cdot}148$.

Regenerator effectiveness	Optimum cycle efficiency	Approx. p.r. at opt. efficiency	Compressor work	Output work	Comp. work / Output work
	Per cent.		kW/lb.	kW/lb.	
0	44·8	6·0	84·18	76·39	1·102
0·2	42·9	9·0	103·00	90·75	1·135
0·4	40·9	10·4	112·08	95·39	1·175
0·5	39·8	13·0	122·42	101·93	1·201
0·6	38·6	15·0	130·68	105·73	1·236
0·7	37·8	17·9	137·39	109·74	1·252
0·8	36·9	19·8	147·31	113·75	1·295
0·9	35·9	22·0	151·78	114·38	1·327
0·95	35·4	24·0	160·79	117·97	1·363
1·0	33·6	30·0	170·15	120·08	1·417

The compressor work:

$$W_c = h_2 - h_b + h_a - h_1 = \frac{C_p T_1}{\eta_c} \left[\left\{ \left(\frac{p_b}{p_1} \right)^{\frac{k-1}{k}} - 1 \right\} + \frac{T_b}{T_1} \left\{ \left(\frac{p_a}{p_b} \right)^{\frac{k-1}{k}} - 1 \right\} \right]. \quad (29)$$

The turbine work:

$$W_t = h_3 - h_m + h_n - h_4 = \eta_t C_p T_3 \left[\left\{ 1 - \left(\frac{p_m}{p_3} \right)^{\frac{k-1}{k}} \right\} + \frac{T_n}{T_3} \left\{ 1 - \left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}} \right\} \right]. \quad (30)$$

The enthalpy change during combustion

$$q = h_3 - h_x + h_n - h_m = h_3 - h_2 - (h_x - h_2) + h_3 - h_m - (h_3 - h_n)$$

$$\frac{q}{C_p} = T_3 - T_2 - \eta_x (T_4 - T_2) + (T_3 - T_m) - (T_3 - T_n). \quad (31)$$

Now

$$\frac{T_4}{T_n} = 1 - \eta_t \left\{ 1 - \left(\frac{p_4}{p_n} \right)^{\frac{k-1}{k}} \right\} \quad (32)$$

$$\frac{T_2}{T_b} = 1 + \frac{1}{\eta_c} \left\{ \left(\frac{p_2}{p_b} \right)^{\frac{k-1}{k}} - 1 \right\} \quad (33)$$

and

$$\frac{T_m}{T_3} = 1 - \eta_t \left\{ 1 - \left(\frac{p_m}{p_3} \right)^{\frac{k-1}{k}} \right\}. \quad (34)$$

Making substitutions for T_4, T_2, and T_m in equation (31),

$$\frac{q}{C_p} = T_3 - (1 - \eta_x) T_b \left[1 + \frac{1}{\eta_c} \left\{ \left(\frac{p_2}{p_b} \right)^{\frac{k-1}{k}} - 1 \right\} \right] - \eta_x T_n \times \left[1 - \eta_t \left\{ 1 - \left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}} \right\} \right] - T_3 \left[1 - \eta_t \left\{ 1 - \left(\frac{p_4}{p_3} \frac{p_m}{p_4} \right)^{\frac{k-1}{k}} \right\} \right] + T_n. \quad . \quad . \quad . \quad (35)$$

The plant efficiency $\eta = \frac{W_t - W_c}{q}$.

To find the pressures for intercooling and reheating for maximum plant efficiency, the efficiency may in turn be differentiated with respect to $\frac{p_4}{p_m}$ and $\frac{p_b}{p_1}$, keeping all other variables constant. The differential is then put equal to zero.

For example,

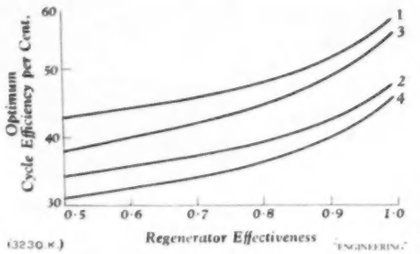
$$\frac{d\eta}{d\left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}}} = \frac{1}{q} \frac{d(W_t - W_c)}{d\left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}}} - \frac{W_t - W_c}{q^2} \frac{dq}{d\left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}}}. \quad (36)$$

This equals zero when

$$\frac{d(W_t - W_c)}{d\left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}}} = \eta \frac{dq}{d\left(\frac{p_4}{p_m} \right)^{\frac{k-1}{k}}}. \quad (37)$$

Making substitutions and differentiating

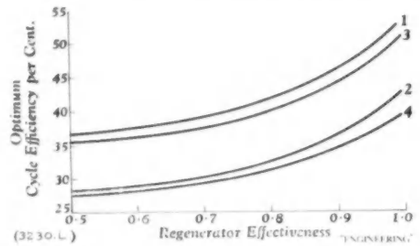
$$\eta_t C_p T_3 \left[\frac{1}{r^{\frac{k-1}{k}}} \left(\frac{p_4}{p_m} \right)^{-2\left(\frac{k-1}{k}\right)} - \frac{T_n}{T_3} \right] = \eta C_p \left[-\eta_x \eta_t T_n + \frac{\eta_t T_2}{r^{\frac{k-1}{k}}} \left(\frac{p_4}{p_m} \right)^{-2\left(\frac{k-1}{k}\right)} \right] \quad . \quad . \quad . \quad (38)$$



Conditions for Fig. 10.

Legend	m	n	$\frac{\Delta p}{p}$	T_3 deg. F.	η at $\eta_x = 0{\cdot}95$
1	4	2	0·148	1,600	54·4
2	4	2	0·148	1,200	44·8
3	4	2	0·200	1,600	52·1
4	4	2	0·200	1,200	42·4

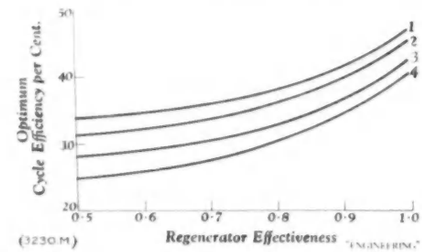
Fig. 10 Efficiency plotted against regenerator effectiveness for various temperatures.



Conditions for Fig. 11.

Legend	m	n	$\frac{\Delta p}{p}$	T_3 deg. F.	η at $\eta_x = 0{\cdot}95$
1	2	1	0·148	1,600	49·3
2	2	1	0·148	1,200	39·0
3	2	1	0·200	1,600	46·9
4	2	1	0·200	1,200	36·3

Fig. 11 Curves for one stage of intercooling and no reheat, for two temperatures.



Conditions for Fig. 12.

Legend	m	n	$\frac{\Delta p}{p}$	T_3 deg. F.	η at $\eta_x = 0{\cdot}95$
1	3	2	0·148	1,200	44·1
2	2	2	0·148	1,200	42·3
3	2	1	0·148	1,200	39·0
4	1	1	0·148	1,200	37·2

Fig. 12 Curves showing the effect of varying the number of stages of intercooling and reheat.

or

$$(1-\eta)\left[\frac{1}{r^{\frac{k-1}{k}}}\left(\frac{p_m}{p_4}\right)^{2\left(\frac{k-1}{k}\right)}\right] = \frac{T_n}{T_3}(1-\eta\,\eta_x) \quad . \quad . \quad . \quad (39)$$

or

$$\frac{p_m}{p_4} = \left[\frac{T_n(1-\eta\,\eta_x)}{T_3(1-\eta)}\right]^{\frac{k}{2(k-1)}} \times \sqrt{r} \quad (40)$$

where r = the pressure ratio $= \frac{p_3}{p_4}$.

Similarly for $\frac{p_b}{p_1}$ the maximum plant efficiency is obtained when

$$\frac{p_b}{p_1} = \left[\frac{T_b}{T_1}\{1-\eta(1-\eta_x)\}\right]^{\frac{k}{2(k-1)}} \times \sqrt{r}. \quad . \quad . \quad . \quad (41)$$

For plants with regenerator effectiveness, η_x, of unity, $T_b = T_1$ and $T_n = T_3$, the pressure ratio for optimum intercooling and reheat is the square root of the overall pressure ratio. Under these conditions the efficiency is

$$\eta = 1 - \frac{(\sqrt{r})^{\frac{k-1}{k}}}{\eta_t\,\eta_c\left(\frac{T_3}{T_1}\right)} \quad . \quad (42)$$

i.e., larger than the efficiency of the (CBT) X_r cycle at the same pressure ratio. For other conditions, values of intercooling and reheat pressures may be obtained from the equations by substituting approximate values of the plant efficiency with subsequent successive substitutions.

ANALYSIS OF VARIOUS GAS-TURBINE CYCLES

Consider a gas turbine with $(m-1)$ intercoolers, $(n-1)$ reheaters and a regenerator. Assume that the enthalpy-entropy diagram is similar to that shown in Fig. 9. The temperature at entry to all the m compressors is the same, as is the work done in each of them. Similarly, the entry temperature and work for each of the n turbines is the same. It is assumed that the flow in the turbines is the same as that in the compressors. From the diagram Fig. 9,

$$q = h_3 - h_x + \frac{n-1}{n}W_t \quad . \quad (43)$$

where W_t is the sum of the work in all the turbines.

Therefore

$$q = (1-\eta_x)(h_3-h_1) + W_c\left[1-(1-\eta_x)\left(\frac{1}{m}+\frac{1}{n}\right)\right] + W\left(1-\frac{1-\eta_x}{n}\right) \quad (44)$$

where W_c is the sum of the work in all the compressors, $W = W_t - W_c$, and η_x is redefined as $\frac{h_x - h_2}{h_4 - h_2}$ which is slightly different from the earlier definition if the effect of varying specific heats is taken into account.

Then

$$\frac{1}{\eta} = \frac{q}{W}$$

$$= \frac{(1-\eta_x)(h_3-h_1) + W_c\left[1-(1-\eta_x)\left(\frac{1}{m}+\frac{1}{n}\right)\right]}{W} + \left(1-\frac{1-\eta_x}{n}\right) \quad (45)$$

This expression also lends itself to a graphical method of determining the optimum pressure ratio. The minimum value of the first term on the right-hand side of equation (45) can be found by plotting W against W_c and drawing a tangent to the curve for W from the point on the W_c axis which is given by

$$\frac{W_c}{h_3 - h_1} = -\frac{1-\eta_x}{1-(1-\eta_x)\left(\frac{1}{m}+\frac{1}{n}\right)} \quad (46)$$

It will be noted that the pressure ratio for maximum work and maximum efficiency coincide when

$$(1-\eta_x) = \left(\frac{m\,n}{m+n}\right). \quad . \quad (47)$$

The above method will not necessarily give the most efficient cycle which can be obtained for given thermodynamic conditions, since for optimum efficiency the pressure ratios across the compressors may not necessarily be equal. As can be seen from equation (41), however, the error is small when regenerators of high effectiveness are used. The same applies to the turbines.

To take account of the duct losses, etc., it is possible to use the method given in the Appendix in which the values of $\frac{\Delta p}{p}$ in each component are summed, and the total loss is introduced at inlet to the first turbine as the following example shows.

NUMERICAL EXAMPLES

Consider first a plant in which $m = 4$, $n = 2$; $\eta_c = 0{\cdot}87$; $\eta_t = 0{\cdot}91$; $\Sigma\frac{\Delta p}{p} = 0{\cdot}148$; $T_3 = 1{,}200$ deg. F.; $T_1 = 68$ deg. F. The calculations for determining W_c and W are summarised in Table I. The volume, *Gas Tables*, referred to in the final entry of the bibliography is used for the properties of air. The pressure at inlet to the turbine for any given compressor pressure ratio is reduced by $\frac{\Delta p}{p} = 0{\cdot}148$ so that $r_t = r\left(1-\frac{\Delta p}{p}\right) = 0{\cdot}852\,r$, where r is the compressor pressure ratio and r_t the turbine expansion ratio. It should be noted that these pressure ratios are slightly incorrect since in the analysis the intercooler and duct losses are transferred to the turbine inlet. However, as the Appendix shows, the value of the compressor work is unaffected by this analytical device.

On the curve of the figures for W against W_c* from Table I, tangents are drawn from points determined by equation (46) to determine values of W_c for optimum efficiency. Values, at the optimum efficiency, of W_c, W, $\frac{W_c}{W}$ and efficiency are given in Table II. The efficiency is plotted against regenerator effectiveness in Fig. 10, curve 2.

A further series of calculations have been made for $T_3 = 1{,}600$ deg. F. and the results are also shown in Fig. 10, curve 1.

The effect of varying the pressure loss is also shown in Fig. 10, in which curves 3 and 4 are drawn for $\Sigma\frac{\Delta p}{p} = 0{\cdot}200$ instead of the value of 0·148 used for curves 1 and 2.

For a similar cycle in which $m = 2$ and $n = 1$, i.e., one stage of intercooling and no reheating, Fig. 11 has been prepared. This is drawn for $T_3 = 1{,}600$ deg. F. and $T_3 = 1{,}200$ deg. F. To show the effect of varying the number of stages of intercooling and reheat, Fig. 12 has been prepared for $T_3 = 1{,}200$ deg. F. and $\Sigma\frac{\Delta p}{p} = 0{\cdot}148$

These curves show clearly the advantages to be gained by increased intercooling and reheating assuming no penalty is incurred in increased

* W_c is used as abscissa instead of $r^{\frac{k-1}{k}}$ for convenience. As $W_c = \frac{C_p T_1 (r^{\frac{k-1}{k}} - 1)}{\eta_c}$, this is equivalent to using $r^{\frac{k-1}{k}}$ with change of scale and origin.

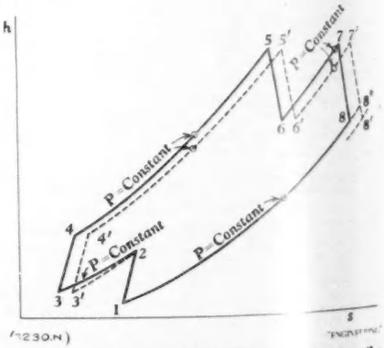


Fig. 13 Enthalpy-entropy diagram showing the effect of ducting losses

pressure losses. Fig. 10 shows, however, that these advantages may easily be lost if pressure losses are increased. The great increase of cycle efficiency with increased T_3 is shown also in Fig. 10, and emphasises the value of techniques such as blade cooling which may permit the use of higher gas temperatures in the turbine.

CONCLUSION

The graphical method outlined enables a number of the calculations of gas-turbine cycle efficiencies to be performed quickly. The degree of accuracy is that suitable for project calculations in which the influences of varying a number of parameters have to be rapidly assessed. Pressure losses may be satisfactorily allowed for. The few examples given illustrate the important influence of regenerator effectiveness, maximum temperature, pressure losses and number of stages of intercooling and reheating on the gas-turbine power plant.

APPENDIX

Effect of ducting losses on performance

Any irreversibility occurring in parts of the plant other than the turbine or compressor may be considered to be due to a drop in pressure at constant enthalpy. Taking as an example a plant with one stage of intercooling and one of reheating, an enthalpy-entropy diagram may be drawn for such a plant in which there are no ducting losses, as in Fig. 13, and in which the process is described by points 12345678. When ducting losses occur and if none of the temperatures are changed, the process may be shown as 123′4′5′6′7′8′.

Now $\frac{p_{3'}}{p_3} = \frac{p_{4'}}{p_4}$ if $\frac{p_4}{p_3} = \frac{p_{4'}}{p_{3'}}$.

Since $T_3 = T_{3'}$ and $T_4 = T_{4'}$ this condition will be satisfied if the efficiency of the process 3—4 is the same as that for 3′—4′, and if the specific heats are constant. With similar conditions for the efficiencies of 5–6, 5′–6′ and 7–8, 7′–8′ :

$$\frac{p_{3'}}{p_3} = \frac{p_{4'}}{p_4} = \frac{p_{5'}}{p_5} = \frac{p_{6'}}{p_6} = \frac{p_{7'}}{p_7} = \frac{p_{8'}}{p_8}$$

since $p_4 = p_5$, $p_{4'} = p_{5'}$, and $p_6 = p_7$, $p_{6'} = p_{7'}$.

Hence the process 123′4′5′6′7′8′ will have the same work output and change in enthalpy in the combustion chamber as process 12345678 with the same compressor and turbine efficiencies. To achieve this, it is necessary that the turbine exhaust pressure be lowered from p_8 to $p_{8'}$, where

$$\frac{p_{8'}}{p_8} = \frac{p_{3'}}{p_3}.$$

In practice the exhaust pressure is generally fixed so that the plant with the intercooler pressure loss has the turbine exhaust condition shown as 8″ in Fig. 13. Hence its turbine work is reduced below that of the equivalent plant 12345678 by an amount $h_{8''} - h_{8'}$ B.Th.U. per lb.

Suppose that a pressure loss occurs only in the intercooler from 3 to 3′ and write $\frac{p_{3'}}{p_3} = 1 - \frac{\Delta p}{p}$ where $\frac{\Delta p}{p}$ is the ratio of the pressure loss to the initial pressure in the intercooler system, then $\frac{p_{4'}}{p_4} = 1 - \frac{\Delta p}{p}$.

Similar conclusions may be drawn for losses occurring in any other part of the plant such as combustion chambers, ducts or regenerators. The effect of these losses may be shown as a reduction of work in the turbine of an equivalent plant without such losses, and with the same temperatures and efficiencies in compressors and turbines. Alternatively all the values of $\frac{\Delta p}{p}$ may be summed giving the result that

$$\frac{p_{5'}}{p_5} = \text{product}\left(1 - \frac{\Delta p}{p}\right)$$

which if the values of $\frac{\Delta p}{p}$ are small, gives the result

$$\frac{p_{5'}}{p_5} = 1 - \Sigma\frac{\Delta p}{p}.$$

The cycle calculation may now be performed with a pressure at the turbine inlet of p_5' instead of p_5.

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CAMBRIDGE UNDERGRADUATES VISIT INSTRUMENT-MAKING WORKS

In their final year science undergraduates at Cambridge University are invited to an "At Home" held by the Cambridge Instrument Company, Limited, in Chesterton-road, so that they may see something of the manufacturing methods of the firm and examples of its products. Heads of colleges, teaching staff, research workers and senior laboratory assistants of the University are also invited, together with local dignitaries and certain graduates in the district. This year, in which the company celebrates the 75th anniversary of its formation, the visits were arranged for the afternoons of Wednesday and Thursday, April 25 and 26.

The Cambridge works are now devoted mainly to the construction of industrial apparatus, physical instruments and apparatus for special applications. Electrical instruments and apparatus are generally made in the Company's works at Muswell Hill, London, and another works in the London area, at North Finchley, is devoted to the production of instruments and apparatus for mechanical thermometry. The head office and showrooms are at 13 Grosvenor-place, London, S.W.1. Examples of the products of the two London works were exhibited and demonstrated during the visits, in addition to those made at Cambridge.

Of particular interest was the research department which forms a large and important part of the works. In addition to investigations necessary to the design of new instruments, much development work is carried out here up to the stage of industrial use; a number of prototype instruments in course of development could be seen. The main instrument assembly shop is divided into two portions dealing, respectively, with industrial and scientific instruments. The former include temperature indicators and recorders, other than those of the expansion type, which are made in the North Finchley works. One of the demonstrations arranged in the assembly shop showed vibrographs, accelerometers, stress recorders and other instruments employing a system of marking with a metal stylus on celluloid tape which does not involve cutting or scratching the celluloid, the material being merely displaced.

The main machine shop is divided into four bays, one of which is devoted to work in connection with thermocouple and resistance-type thermometers. Capstans and automatics for small parts are accommodated in a second bay and the heavier machine tools, including millers, a horizontal boring machine and multi-spindle drilling and tapping machines are located in a third bay. Other machine tools are provided in the tool room where tools and jigs were shown under construction. The remaining bay is used for grinding and polishing and sand-blasting operations. Other departments of the works are devoted respectively to heat treatment, electric wiring and assembly, and enamelling. In the electrical wiring shop, the winding and testing of instrument coils and the mounting and suspension of indicators and recorders are carried out. In the enamelling shop lacquering and enamellingof instrument parts is done by spraying, and castings and fabricated parts are prepared for enamelling. The drying oven used in this department is of the infra-red type and the work is traversed through it on a variable-speed conveyor which ensures a smooth and uniform finish.

The gas analysers, which form an important section of the company's business, generally function on the thermal-conductivity principle. The construction and adjustment of the katharometer units for these instruments was shown in progress in the gas-analysis department of the works. In addition to measuring units for carbon monoxide, carbon dioxide, hydrogen and dissolved oxygen, humidity recorders, micro-vacuum gauges, etc., are also made in this department. The method of bulk standardisation employed is noteworthy. The testing and standardisation of much of the apparatus made in the works, particularly that for temperature measurement and electrical standardisation, is carried out in the test room. The instruments under test at the time of the visit included thermo-electric and resistance temperature indicators and recorders, radiation and disappearing-filament pyrometers and illuminated moving-scale instruments; several other types of instruments such as electrometers, fluxmeters and a textile extensometer were demonstrated.

As the reputation which the company has achieved for the quality of its products still depends to a large extent on high-class craftsmanship the method employed for training apprentices may be referred to briefly. Boys enter the works at the school-leaving age and usually spend about a year in the apprentice department. Here they are taught simple hand and machine operations and workshop processes such as soft and hard soldering, hardening and tempering. In general the work during the first year is applied to the production of hand tools which the apprentices retain for their own use. Under the supervision of an experienced craftsman the boys acquire sufficient knowledge to be useful in the shops where they continue their apprenticeship for another five years. It will be obvious that the preliminary training enables those boys who have no natural aptitude for engineering work to be diverted to other employment at an early stage, thus avoiding waste of effort, time and material as far as possible. In general from 12 to about 20 boys enter the works each year for preliminary training and not more than three or four of them, on an average, fail to complete the full course.

At the present time the company's employees number over 1,100 of whom about half are occupied at Cambridge.

THE FORMABILITY OF ALUMINIUM ALLOYS

By D. A. Barlow, M.SC.*

Continued from page 332

SECTION III: BENDING

This process (Fig. 12) includes bending of sheet, sections and tube in three-roll, three-point loading and wrap machines, also straight flanging using a punch and die or rubber die press. Three-roll machines are used for large radius curves, the minimum radius being generally determined by the design of the machine rather than by the material. In three-point loading, the maximum bending moment is at the mid-point, so that although fairly uniform bends are obtained by the use of suitable formers, "peaking" and fracture at the mid-point may occur before the remainder of the material has conformed to the radius—this applies particularly to the high-strength alloys which do not work harden rapidly. Wrap type machines have the advantage that an accurate bend is produced and peaking is prevented. The minimum radius obtainable is limited by the ductility or buckling of the part, and the formers and guides can easily be designed to support the sections so as to minimise buckling.

STRUCTURAL SECTIONS AND OTHER OPEN SHAPES

Since aluminium alloys are generally more ductile in compression than in tension, fracture when it occurs is usually in the outer fibre in tension. The common structural sections can be classified according to whether they fail in tension or by buckling (Fig. 13). Referring to Fig. 13, Class A sections generally fail in tension, although buckling may be difficult to prevent on the thinner sections in Class A1. Class C fail by buckling, and in Class B the mode of failure will depend largely on the dimensions of the section. The minimum bend radius for Class C will depend on the support given by the dies. Because the material thickens up in compression, clearance must be provided between the dies and the section, and this will allow some buckling. The minimum bend radii for Class C sections are probably best determined experimentally on a few representative sections so as to obtain empirical relations between the minimum bend radius and section dimensions, since the analysis of plastic buckling problems is usually very difficult.

TUBES

Consideration of the bending of tubes suggests that failure may take place in a number of ways, depending on the wall-thickness : tube-diameter ratio and the conditions of bending. The latter may be classified as follows:

(1) Free bending, with no fitted formers, etc. Data on this method would be useful where small numbers of bends must be made and complete equipment is not available.

(2) External support by grooved formers.

(3) External support by grooved formers and internal support by a flexible mandrel. This method is used in production, where large numbers of bends to the smallest possible radii are required.

(4) External support by grooved formers and internal support by a filler material (e.g., sand, low melting point metal, etc.) which may be compressible.

(5) Internal support by a filler.

The tubes fall into three groups:

(*a*) *Very Thick-Walled Tubing.*—This behaves like rod in bending and the forming limits are similar. Tubing with these proportions is of little practical interest.

(*b*) *Tubes of Moderate Wall Thickness.*—Method (1): The tubes tend to flatten and the failure point is that at which flattening is considered excessive. A figure of 5 per cent. reduction in diameter is often taken in practice. Method (2): The tube fails as in method (1), but the lateral support given by the grooved former reduces the amount of flattening. Method (3): The mandrel prevents flattening and the outer fibres commence to neck on reaching the general elongation in plane strain, because lateral contraction is prevented and (in contrast with the bending of bars) there is little support from the remainder of the material. Method (4): The failure point depends on the mechanical properties of the filler and failure may take place by flattening or by necking as in method (3). Method (5): Failure occurs by flattening, the minimum-bend radius depending on the properties of the filler.

(*c*) *Very Thin-Walled Tubing.*—Methods (1) and (2): Failure will take place by buckling due to longitudinal compression. Method (3): Failure will take place in tension, as for tubes of moderate wall thickness. Methods (4) and (5): Failure may take place by flattening or buckling, depending on the mechanical properties of the filler.

SOLID SECTIONS

In the present discussion solid sections are regarded as comprising compact shapes such as rectangular, round or hexagonal bar etc., where the minimum-bend radius is governed by tensile ductility. The bending of rectangular bars only is examined here, but other compact shapes may be expected to behave in a similar manner.

For rectangular bars the tensile ductility of the outer fibre in bending depends on the width : thickness ratio. Where this ratio is small, say less than 1, the lateral restraint is small, so that as the outer fibres stretch longitudinally they are free to contract laterally, i.e. they are in pure tension; the inner fibres are likewise in pure compression, because they are free to expand laterally. This gives rise to the familiar anticlastic curvature. When the outer fibres reach their maximum load or general elongation, the load on the remainder of the fibres is still increasing. The bending moment on the section as a whole is thus increasing, i.e. the section is stable, so that the outer fibres are supported by the remainder of the bar and deformation continues without local necking or failure over the full length of the bend. Eventually the bending moment reaches a maximum, when the section becomes unstable and local necking followed by fracture occurs. The stage at which the bending moment attains its maximum value depends on the shape of the stress-strain curve, and has been calculated by Dorn and Jelinek[8]; it can be shown that for all commercial aluminium alloys this occurs at an outer fibre strain of 100 to 200 per cent. Observations on gridded rectangular bars show that the material will be bent flat on itself at an outer fibre strain of 75 to 100 per cent., when further bending is impossible. If the section is bent around a former, any local collapse is prevented and fracture only takes place when the local elongation has been exhausted. Dorn, Putman, Jelinek and Thomsen[9] found good agreement between bend and tensile-test results in this way for a number of aluminium alloys.

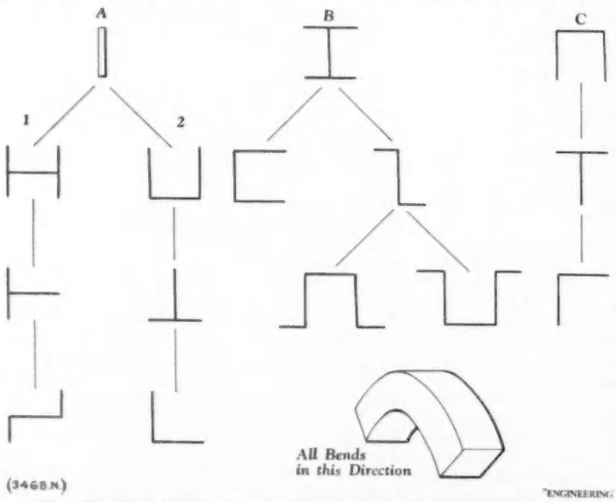

Fig. 13 Classification of common sections by methods of failure.

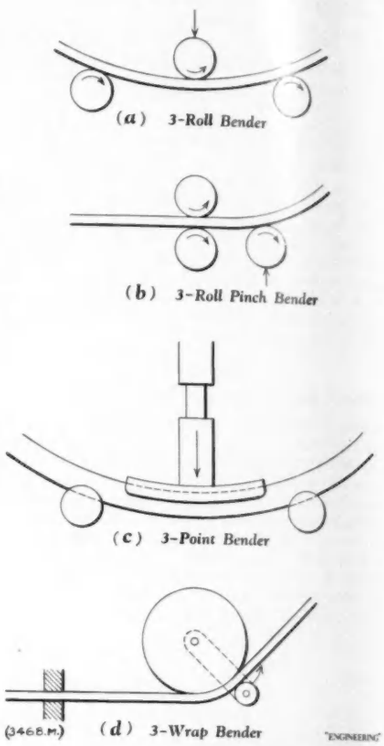

Fig. 12 Bending.

There is evidence from the results of Sachs *et al.*[10] for very narrow rectangular sections where the width : thickness ratio is less than, say, 0·3 (as, for example, strip on edge) that the outer fibre ductility decreases slightly. It is difficult to bend such sections without buckling, but analysis of their behaviour would be interesting as the mechanism of failure may differ from that of slightly wider sections. In very narrow sections, the restraint and therefore support given to the outer fibres by the remainder of the bar is less than in slightly wider sections and may be insufficient to enable the full local elongation to be utilised. In infinitely narrow sections there would be no restraint and no support, so that the section would behave as a number of separate fibres, and necking would commence at the ordinary ultimate tensile stress of the outer fibre; the minimum-bend radius would thus be given by the simple tensile general elongation.

SHEET AND PLATE

In the case of sheet and plate the width : thickness ratios are high, and during bending the edges only are free to strain in the transverse direction, so that a transverse tension is induced in the outer fibres. Under biaxial tension the local ductility is reduced, with the result that the minimum-bend radius is also reduced, to an extent which depends on the width : thickness ratio. With increasing values of the ratio the lateral restraint and corresponding lateral tension increase, until at a ratio of 10 to 20 all lateral strain is prevented (except at the edges) and no further loss of ductility occurs (Fig. 14). If the limiting values of minimum bend radii are known for wide and narrow sections, values for intermediate widths can be estimated with sufficient accuracy for practical purposes from the general shape of the curve in Fig. 14, which is based on tests by Sachs *et al.*[10]

Dorn *et al.*[9] have shown how the minimum-bend radius for wide sections can be calculated. Consider the true-stress/true-strain curve in simple tension (Fig. 15). Fracture occurs at point A, according to a certain law, the maximum principal stress or maximum shear stress fracture criterion being generally accepted for aluminium alloys; both furnish the same result in this case. For wide sections, where there is no lateral strain, it can be shown that the lateral stress $p_2 = \frac{1}{2}$ longitudinal stress, p_1. Elastic strains are neglected and the stress p_3 in the thickness direction is small and can be ignored. It is generally assumed that aluminium alloys yield according to von Mises' hypothesis, which under plane

strain condition, as in this case, gives $p_1 = \frac{2}{\sqrt{3}} f$, where f is the yield stress in simple tension. The stresses in the outer fibre of a wide section can therefore be derived if the stress values of the simple true tensile curve are multiplied by $\frac{2}{\sqrt{3}}$; if the constant total plastic work hypothesis is used the strain values must likewise be multiplied by $\frac{\sqrt{3}}{2}$, giving the stress strain curve in Fig. 15. Point B, where the critical value of maximum principal stress or maximum shear stress is reached, gives the local ductility of the outer fibre, from which the minimum-bend radius can be calculated.

It is unnecessary to re-plot stress-strain curves; the plane strain ductility is 0·866 × the true strain, corresponding to a true stress of 0·866 × the true fracture stress in simple tension. The true-stress : true-strain curve can be determined approximately from the ordinary stress-strain curve. Thus, up to the ultimate tensile stress, true stress = $(1 + e) \times$ nominal stress, where e is the ordinary elongation, $\frac{L - L_0}{L_0}$. The true fracture stress = $\frac{\text{fracture load}}{\text{final area}}$. It is well known that for many materials the true-stress : true-strain curve is approximately a straight line from the maximum load to fracture, so that an approximate curve can be obtained.

It will be realised from the foregoing that the theoretical values for outer-fibre ductility depend on the fracture and yield criteria used, particularly the latter. The author has shown elsewhere[11] that bend-test results appear to throw doubt on the accuracy of von Mises' hypothesis of yielding for some aluminium alloys.

Table 1 gives a comparison between quoted minimum-bend radii and values calculated as above. The quoted values are for 0·064 in. thick sheet expressed in terms of the thickness t, and were obtained on bend test pieces of ½ in. width, giving a width : thickness ratio of 8, corresponding very nearly to infinitely wide sheet. Calculated values of limiting outer fibre strain of over 75 per cent. are given in the table as "flat." It will be seen that good agreement has been obtained.

It should be noted that for narrow sections, the most ductile material in bending is that with the highest local elongation. For wide sections, a low proof stress and a high rate of work hardening, particularly near failure are required in addition to high local elongation. In the case of extrusions, the softest tempers are not always those with the greatest elongation. Thus, all heat treated alloys except BS1476/HE9 and some HE10 compositions (1 per cent. silicon, ½ per cent. magnesium, no manganese, chromium or copper) have a local elongation when artificially aged as great as or greater than that of the naturally aged material; also some alloys have a relatively low local elongation when freshly quenched after solution heat treatment.

With all sections, there is a "pulling in" of material from the straight part adjacent to the bend, and this reduces the actual strain in the outer fibre below the geometrical value on bends of small angle. In bends of small radius the shift of the neutral axis towards the inner fibre increases the outer-fibre strain. There is also a size effect—small sections have a greater limiting outer fibre strain than large ones. Dorn *et al.*[9] has shown that the reasons for this are at least partly metallurgical—thin sheet has a finer grain size and greater zero gauge length elongation than thick sheet.

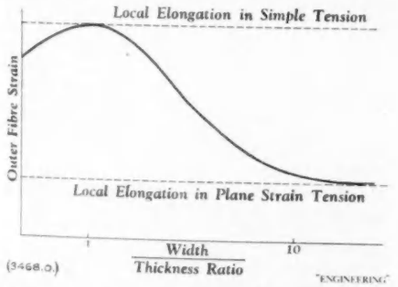

Fig. 14 Variation of ductility in bending with width : thickness ratio (after Sachs *et al*).

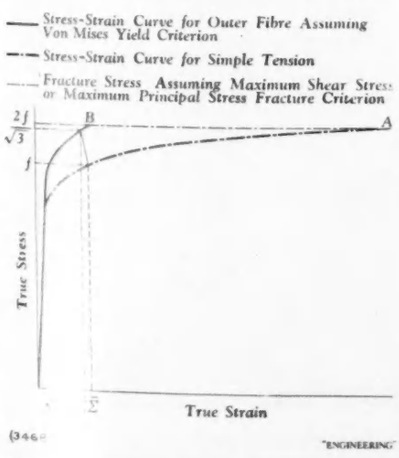

Fig. 7 Determination of ductility of the outer fibres of a wide beam in bending.

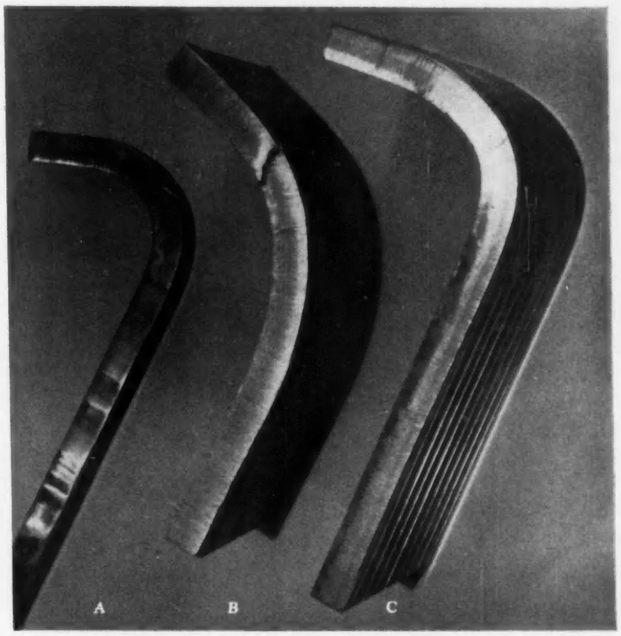

Fig. 16 Minimum-bend radii of, from left to right, A narrow, B wide, and C grooved plate (½ in. thick H15WP).

TABLE 1.—*Quoted and Calculated Minimum-Bend Radii for 0·064 in. thick sheet*

Alloy	Quoted Value	Calculated Value
B.S.1470		
1C—0	Flat	Flat
—¼H	Flat	Flat
—½H	Flat	Flat
—¾H	Flat—½*t*	Flat
—H	½*t*	Flat—½*t*
N3—0	Flat	Flat
—¼H	Flat	Flat
—½H	Flat	½*t*
—¾H	½—1*t*	½*t*
—H	1—1½*t*	1*t*
N4—0	Flat	Flat
—½H	½—1*t*	Flat
N5—0	Flat	Flat
—½H	1*t*	Flat
N6—0	Flat	Flat
—½H	1*t*	½*t*
H15—0	Flat	½*t*
—W	1½*t*	2*t*
—WP	2½*t*	5*t*
H20—0	Flat	Flat
—W	½—1½*t*	1*t*
—WP	1½—2*t*	1*t*

APPLICATION OF THE THEORY TO GROOVED SECTIONS

The reduction in ductility in bending which results from lateral restraint suggests that if the outer surface of a wide section were grooved longitudinally the separate elements would then be free to contract laterally, and ductility equal to that of narrow sections would be obtained. The grooves would have to be of sufficient depth to ensure that the plane strain ductility of the "core" would not be exceeded. This requires the groove depth to be a minimum of:

$$\frac{\text{beam depth}}{2} \times \frac{\left[\begin{matrix}\text{simple tensile local}\\ \text{ductility (per cent.)}\end{matrix}\right] - \left[\begin{matrix}\text{plane strain local}\\ \text{ductility (per cent.)}\end{matrix}\right]}{\text{simple tensile local ductility (per cent.)}}.$$

Grooves are not necessary on the compression side of the bend as the compressive ductility is adequate. The use of grooves in the tension side only shifts the neutral axis towards the compression side because of the altered stress condition in the outer fibre and the removal of material. This has the effect of increasing the outer-fibre strain required of the material for a given bend radius, i.e., increasing the minimum-bend radius. In the worst case, however, the increase in outer-fibre strain is about 6 per cent. for grooves of negligible width, and 9 per cent. for a total groove width of 10 per cent. of the section width, so that provided the grooves are not too wide they need be on the tension side only and the minimum-bend radius of the wide section will be almost the same as a narrow one. Fig. 16 shows narrow and wide specimens of ½ in. thick H15WP plate (A and B) bent to the minimum bend radii. Specimen C is a similar piece of plate but has machined grooves, and the minimum-bend radius is now the same as for the narrow specimen.

In practical applications of this principle, a grooved or fluted section could be used where severe bends are required and where transverse stresses in service are small. A section of this type has already been used for aluminium alloy benk bars (mine roof supports)[12, 13] which are subjected to repeated plastic bending and straightening in service. The minimum-bend radius of the benk bars is not important, but the increased ductility gives them a longer life. Longitudinal grooves are used in these bars for other reasons, but it is probable that the effect demonstrated here has been a factor contributing to their satisfactory mechanical performance. Similar considerations doubtless apply to conventional steel benk bars, which are of a troughed or corrugated section.

SECTION IV: DEEP DRAWING

Single-stage deep drawing consists in pulling a sheet blank through a die by means of a flat-bottomed punch, the metal being allowed to move freely into the die but not to wrinkle, so that the finished shape is formed chiefly by compression of the periphery of the blank (Fig. 17). The cup can be re-drawn if necessary in a similar manner, to give a deeper cup of smaller cross section.

In deep drawing, if the blank is thick, little or no wrinkling occurs, and a conical die is often used so as to suppress further any tendency to wrinkle; if it is thin, wrinkling is generally prevented by a spring- or pneumatically-loaded blank holder or pressure plate. The blank holder pressure should be just sufficient to obviate wrinkling—high loads put an additional load on the cup walls. Another method of preventing wrinkling is to use a fixed blank holder with a clearance of about 5 per cent., as in a double-acting press; this clearance prevents wrinkling yet is sufficient to allow thickening on thin shallow parts; thick deep parts require more clearance near the die throat, the amount depending on the rigidity of the tools.

Where there is insufficient radial clearance between punch and die to allow the thickened sheet to pass freely, ironing or thinning of the cup walls takes place. This will be considered in Section V. To avoid all ironing a radial clearance of up to 50 per cent. of the original sheet thickness is needed, but

the finished cup is then bell mouthed. This is avoided in practice by using a smaller clearance, say 30 per cent.; still smaller clearances, 20 per cent to 10 per cent., are often used to give a mild ironing action and produce a deeper cup of more uniform wall thickness. With this amount of ironing the additional load is not excessive and it occurs near the end of the stroke, where the drawing load is well past its peak, consequently the maximum reduction obtainable in deep drawing is not impaired. The minimum clearance that can be used without affecting the maximum reduction in deep drawing is around 5 per cent. In practice a clearance of 10 per cent. on the nominal stock thickness is used to allow for the usual ± 5 per cent. tolerance.

MODES OF FAILURE IN DEEP DRAWING

There are four ways in which failure in deep drawing can take place. In the first place, compression failure occurs in the form of a 45 deg. shear

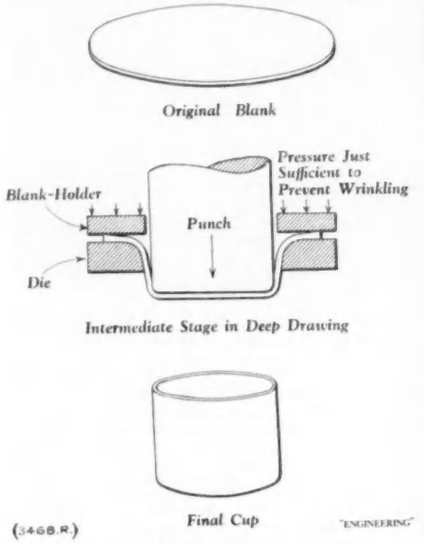

Fig. 17 The deep-drawing process.

crack in the rim or flange of the cup, due to insufficient ductility of the material in simple compression (the rim is in substantially pure compression during drawing).

Secondly, tensile failure can take place high up in the wall of the cup, after the maximum load has been passed. The material near the top of the cup has to withstand a stretch of up to 60 per cent. in the radial direction towards the end of the operation, under the action of the applied radial tension and induced circumferential compression. Because of this circumferential compressive stress the tensile ductility of the material in the radial direction is increased, so that materials with very little ordinary tensile elongation can withstand the necessary extension without failure, which only takes place in rather brittle materials, often when compression failure is imminent. This type of upper-wall tensile failure is not to be confused with tensile failures in ironing caused by attempting too great a reduction in wall thickness or by breakdown of the lubricant.

In the third place, a second type of tensile failure takes place at the neck in the wall near the junction with the bottom radius (punch-profile radius). This neck is produced by the plastic bending and straightening under tension which occurs as the sheet is pulled over the die-profile radius. The double flexure results in thinning in a region of the cup which receives very little other deformation, so that it appears as a neck. Further up the cup wall, this thinning, which occurs throughout the draw as the sheet is pulled over the die-profile radius, is masked by the considerable thickening which takes place as a result of circumferential compression. The severity of the necking depends upon the die-profile radius and the rate of work-hardening of the material. A die-profile radius of $10t_0$ is preferred (where t_0 is the original sheet thickness); beyond $10t_0$ there is little further advantage. With very large die-profile radii wrinkling is more difficult to control, because the area of sheet in contact with (and therefore controlled by) the blank holder is reduced; when the tendency to wrinkle is severe it may be necessary to use a very small die-profile radius.

In the fourth place, a third type of tensile failure and the most common mode of failure in deep drawing is that which occurs over the punch-profile radius, at the neck produced by plastic bending under tension as the sheet is formed to the punch profile. If other conditions are favourable for deep drawing, failure takes place in this region when too great a reduction is attempted. The optimum punch-profile radius is generally greater than $4t_0$, depending on the material and the punch-diameter : sheet-thickness ratio. With a very small punch-profile radius necking is very severe; with a large punch-profile radius (say, $10t_0$ to $20t_0$) considerable general thinning takes place as the sheet is stretch-formed to the punch contour. At intermediate curvatures the thinning is a minimum although it does not always follow that this condition will give the maximum reduction in deep drawing.

DESIRABLE CHARACTERISTICS OF MATERIALS FOR DEEP DRAWING

To obtain the deepest draws the requirements of the material are therefore as follows: Firstly it must have sufficient compressive ductility to withstand the reduction in diameter of the blank to form the cup. The largest reduction likely to be obtainable in deep drawing is 55 per cent., and this requires up to 55 per cent. contraction in length in a compression test. (Reduction in deep drawing is defined as $\frac{\text{Blank diameter} - \text{Mean cup diameter}}{\text{Blank diameter}}$ per cent.)

Secondly, it must have sufficient general elongation under combined stress to avoid upper-wall failure. In terms of elongation in simple tension this is small and failure generally occurs only in materials in which compression failure is imminent, so that if the first condition is satisfied the tensile ductility will probably be adequate.

Thirdly, it must have sufficient tensile ductility to withstand bending under tension over the punch and die-profile radii without failure. If these radii are not too small or too large all alloys and tempers will withstand this.

Fourthly, the ultimate tensile stress should be high in relation to the compressive properties. The compressive properties determine the major portion of the load and the ability of the cup walls to take this load is determined approximately by the simple ultimate tensile stress.

It follows from these requirements that tensile ductility is no measure of deep drawability and is of importance only where punch and die-profile radii must be small, or the punch-profile radius very large. In fact, the very brittle materials generally fail in deep drawing for lack of compressive ductility. It should be added that tensile ductility gives little indication of compressive ductility; most alloys are far more ductile in compression than in tension, but much greater ductility in compression than in tension is called for in deep drawing. With regard to the fourth requirement, it does not follow that a soft material has any advantage over a hard one; in fact the reverse is usually the case—the hard alloys do not work-harden so rapidly in compression, so that although the compressive stresses of different tempers of an alloy are widely different at small deformations the relative differences become much less at large deformations.

To be continued

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CLIMBING CRANE

Mast Extends as Building Height Increases

The advent of the skyscraper and the general increase in building heights which has occurred in recent years has resulted in construction problems calling for cranes of special design, superior in performance to ordinary tower cranes, which at heights above 150 ft. develop dangerous stresses and strains in the mast. In addition, crane drivers operating orthodox cranes are rarely able to see both the loading and unloading points and are therefore dependent on the signals of a banksman. A final consideration concerns the restricted space usually available on building sites and the inconvenience of using a crane with a bulky undercarriage—a necessary feature in cranes which slew from the base. To overcome these difficulties, the "Everest" climbing crane, which can be aligned to a gradual increase in building height up to 300 ft. and is economical in ground space, has been developed by Friedrich W. Schwing, G.m.b.H. of Wanne-Eickel, Germany. It is marketed in this country by George Cohen, Sons and Company, Limited (the 600 Group), Wood-lane, London, W.12.

The "Everest" climbing crane is a three-purpose installation: the crane itself, a passenger and material lift, and a concrete-bucket hoist. The unit can be set up within the building, and the mast sections are placed, anchored and lifted inside the lift shaft. Slewing takes place from the head of the crane, which is made up of a 43 ft. long horizontal jib with its crab, the counterweight on which the winch is mounted, the top boom and the control cabin. There is full 360 deg. slewing and the operator in his control cabin just below the horizontal jib has a full view of the hook and load in all working positions. The operating height can be quickly stepped up a storey at a time until 300 ft. is attained, while the telescopic under-section of the mast is lifted by an electrically driven screw.

The passenger and materials lift, located outside the mast, takes men to the operating level at 180 ft. per minute. Outside the mast there is the concrete hoist which consists of two skips, each of 18 cub. ft. capacity, for taking the concrete mixed on the ground to the working level, where it is accurately placed by the crane hook. Thus the hook deals wholly and uninterruptedly with the task in hand, without the distraction of subsidiary supply requirements.

The crane has a capacity of 23 cwt. at any radius from 4 ft. 10 in. to 43 ft. and it has a lifting speed of up to 150 ft. per minute. Maximum crab and slewing speeds are 90 ft. per minute and 1 r.p.m., respectively. Another model is also being made—the KTK 25—with a lift of 2,750 lb. at 66 ft., a height of 300 ft. with a lifting speed of 230 ft. per minute. This unit incorporates remote control, but is without the refinements of passenger and bucket hoists.

Designed for construction work, the "Everest" climbing crane can be adjusted to a gradual increase in building height up to 300 ft. The crane slews from the head of the extending mast.

Book Reviews

UNDERWATER WANDERERS

The Master Diver and Underwater Sportsman. By Captain T. A. HAMPTON. *Adlard Coles, Limited* (in association with *George G. Harrap and Company, Limited*), 7 *Brunswick-place, Southampton.* (15*s.*)

It is nowadays fashionable to talk about diving with self-contained compressed-air apparatus, generally known as the "Aqualung," as the modern method, and to consider all other forms of diving as out-of-date. Certainly the advent of this apparatus, with its entirely automatic supply of air and its freedom from any direct connection with the surface, has introduced men of all walks of life, and women and children too, to the excitement of underwater exploration. In recent years hundreds of people in this country alone, who previously would have been horrified at the thought of diving, have taken up underwater swimming as a summer sport and pastime. Those who have been lucky enough to holiday abroad have found delight in observing the beauties of fish and marine vegetable life in the ideal conditions of warm and clear water.

In more serious vein the Aqualung has been used for archaeological surveys, seaweed investigations and the exploration of wrecks and submerged villages. The mobility conferred on the diver has enabled rapid surveys for salvage and repair purposes to be carried out, while the portability of the apparatus out of the water has facilitated diving operations at inland sites, beyond the reach of the diver equipped with more cumbersome apparatus. It is perhaps questionable whether all these activities would have been impossible without the Aqualung, but there is no doubt that the popularity of the apparatus, and the enthusiasm of its users, has provided the necessary spur for the execution of this work which might otherwise never have been attempted.

However, it is a mistake to think that the Aqualung has superseded every other type of equipment. In less romantic spheres it may well be found wanting. Its very lightness underwater, its limited duration and lack of physical protection of the wearer are all disadvantages in the routine work of docking down ships, inspecting moorings and repairing jetties and piers. Only those who, in the pitch blackness beneath a ship, have encountered the savagery of stranded wire rope around a propeller, or of torn steel plates inside a wreck, can appreciate the protection of a metal helmet and a heavy twill diving dress. The skill needed to operate an oxy-hydrogen cutting torch while tugs and barges move close by with constant heavy washes, calls for the steady anchorage of a pair of 18 lb. lead boots. In the filthy murk of some harbour bed there is no more reassuring sound than the steady plod of compressor or pump sending down fresh air for hours on end.

Unlike so many authors to-day, who have rushed into print about diving after only sampling the sun-dappled tideless waters of the Mediterranean, Captain T. A. Hampton has not made the mistake of eulogising the Aqualung to the exclusion of all else. While coming out strongly in favour of this apparatus, Captain Hampton, in a well ordered survey, has covered the essential points of diving with every other type of apparatus in common use to-day. His technical descriptions and operating instructions for each type of gear are simple and clear, while he gives a sensible outline of training for beginners which cannot fail to be of enormous help to those striving to become proficient and useful divers.

In addition to the actual diving gear, Captain Hampton also describes the essential tools of the diver's trade, such as cutting equipment, lighting gear, demolition charges, and includes useful advice on seamanship, and the law of salvage. He has written this book in the light of his own experience, mostly gained in running his Underwater Centre at Dartmouth. He would perhaps have been better advised to steer clear of subjects such as oxy-helium deep diving, of which he obviously has not the same experience. It is also perhaps unwise to publish at the end a decompression table, of American origin, which is not generally accepted by diving authorities in this country, without the copious instructions issued with it by the U.S. Navy. Readers will be disappointed to find no reference in the text to the acquisition of the "British Master Diver's Certificate" mentioned on the dust cover. This certificate is not generally recognised and is not issued by any authority, so that some guidance as to its meaning and the essential qualifications to achieve it would have been welcome.

It is a mistake to think that the Aqualung has superseded heavier forms of diving equipment. Only those who, in the pitch blackness beneath a ship, have encountered the savagery of stranded wire rope can appreciate the protection of a metal helmet and a heavy diving dress.

★ ★ ★

PIONEERS IN MANAGEMENT

The Golden Book of Management: A Historical Record of the Life and Work of Seventy Pioneers. Edited for the International Committee of Scientific Management (CIOS) by L. URWICK. *Newman Neame, Limited,* 50 *Fitzroy-street, London, W.*1 (35*s.*)

The question whether management is a science or an art has never been in doubt for the devotees of that esoteric cult which is known as "The Management Movement" and whose revered high priest in this country is Lieut.-Colonel L. Urwick. "Movement" is perhaps a strange designation for the activities of a group of people who claim that they are bringing the principles of scientific method and cool logical analysis to the task of directing and controlling human activities in industry, commerce and public administration. Although F. W. Taylor is generally spoken of as the father of scientific management, there were many before him who brought inquiring minds and sometimes tender hearts to the problems which arose in the businesses with which they were connected. It was this thought which led the International Committee of Scientific Management in 1951 to invite Colonel Urwick to collect material for and edit a historical record of the life and work of seventy pioneers who are no longer living.

One of the surprising things about the movement is that its standards are so low—and that applies also to this book. This is not only demonstrated by the undistinguished format and binding and the atrocious illustrations, but also by the choice of subjects which seems at times almost frivolous. It is true that, in addition to Taylor, the well known names of Gantt, Gilbreth, Fayol, Rathenau, Rowntree and Elton Mayo are given pride of place. There are also included a number of pioneers from much earlier days, such as James Watt, Matthew Boulton, Robert Owen and Charles Babbage (the progenitor of the modern electronic computer). Some of the others, however, seem to have made little more contribution to original thought than many a successful businessman, engineer or industrial consultant who has joined some association and occasionally contributed an article to a technical journal. The contributions of many of them were made in very narrow fields; these include such men as James Rowan and Frederick Halsey whose only claim to fame was their invention of premium bonus systems which prevented excessive earnings at a time when methods of rate-fixing were extremely crude. Americans predominate but it is difficult to believe that, with few exceptions, the work of most of them could not be found to have been duplicated in any industrial country. Cost accountants, psychologists, production controllers, editors of handbooks are among those thought worthy of inclusion in this heterogeneous collection of no doubt admirable men (and one woman—Mary Parker Follett) and, as a contribution from South America, two politicians. A number of the early theoreticians came from France—which provokes the question why, in spite of this, French industry has remained so extraordinarily backward, particularly in organisation.

Little can be learnt from these little biographies about what nature of men most of these pioneers were, nor how effective the more theoretical of them were in carrying out their ideas in practice. There is a story to be told about the advance in management ideas and practice since the inception of the industrial revolution and Colonel Urwick is well equipped to tell it; but it must be told with a degree of scientific scepticism incompatible with the fervour of a "movement" and its characters must be judged by standards more comparable with those by which historians judge the work of innovators in other fields of human endeavour.

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Proceedings of the Bournemouth Conference of the National Smoke Abatement Society, 1955. *National Smoke Abatement Society, Palace Chambers, Bridge-street, London, S.W.*1. (12*s.* 6*d.*)

The *Proceedings* contain all the papers presented at the Conference, together with their ensuing discussions. A verbatim account of the opening session of the Conference, in which questions on the Clean Air Bill were answered by the Rt. Hon. Alfred Robens, M.P. and Mr. Gerald Nabarro, M.P., is also included. The subject matter of the papers presented includes: recent progress in domestic heating by centralised methods; local authorities, the Beaver report, and the Clean Air Bill; and the Des Voeux Memorial Lecture on the destructive effects of air pollution on materials.

Abridged Building Classification (ABC), 1955. Second edition. Published by the *Section Documentation of the International Council for Building Research, Studies and Documentation, Bouwcentrum, Rotterdam, Netherlands.* Distributed in Great Britain by *British Standards Institution*, 2 *Park-street, London, W.*1. (23*s.* 6*d.*)

This publication consists of a schedule of numbers, selected from the Universal Decimal Classification, as being particularly applicable to architecture, building and civil engineering. The schedule has been developed by the International Building Classification Committee over five years from the Ministry of Works Library abridged schedule. Fifteen countries are represented on the Committee. The classification is presented in a handy form for use in architects' and builders' offices, as well as by specialist building libraries, for filing information.

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy. Vol. 3: Power Reactors. *H.M. Stationery Office, Kingsway, London, W.C.*2. (54*s.*)

Probably the most comprehensive survey to date of unclassified information on the non-military applications of nuclear science was that presented during the International Conference on the Peaceful Uses of Atomic Energy held last August in Geneva. The Proceedings in English have now been published in full, and comprise all the papers submitted (about 1,050), including those not actually delivered during the Conference, and the text of the discussions which took place during the various sessions. There are sixteen volumes in all dealing with different aspects of the subject; the last volume is a record of the Conference and gives a numerical index of the papers, an index of authors, a list of delegates, reports of the opening and closing sessions and the complete texts of the evening lectures. The present volume, " Power Reactors," provides a complete survey of all nuclear reactors throughout the world designed for use in central power stations, and an analysis of the various kinds of fuel cycle. It includes the discussions that followed presentation of the papers and a tabulated catalogue of all the reactors described and their characteristics. It is well illustrated with drawings, diagrams, graphs and half-tone prints.

Investigations into the Optimum Dimensions for Countersunk Points for Aluminium Rivets, Particularly for Marine Work. By A. W. BRACE and A. B. WATTS. Research Report No. 30. *The Aluminium Development Association*, 33 *Grosvenor-street, London, W.*1. (7*s.* 6*d.*)

The report describes tests to provide basic information which will help to establish the relationship between depth of countersink, angle of countersink and strength in tension of light-alloy rivets. Following an account of the materials used in these tests and a brief reference to the choice of countersink profiles, driving conditions are described. The tests themselves—single shear and tensile tests—are then outlined, following which the discussion of results forms the main section of the report. In conclusion there is a summary of the results of the investigation, indicating desirable form and dimensions for light-alloy countersunk rivets.

Practical Construction of Warships. By R. N. NEWTON. Second edition. *Longmans, Green and Company, Limited*, 6 *and* 7 *Clifford-street, London, W.*1. (50*s.*)

Of the first edition of this book, which was published in 1941, six impressions were made, and this second edition includes most of the original material, but has been brought up to date and supplemented to cover new or alternative methods of construction, of which several have been evolved during the last 14 years. The book is divided into four parts: Part I, building structure; Part II, fitting out; Part III, general, and Part IV, special types of ships. The author has served in the Department of the Director of Naval Construction, Admiralty, and in the Royal Dockyards, and is at present Deputy Superintendent at the Admiralty Experiment Works, Haslar.

Process Planning. By RAYMOND H. DIPPLE. *The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (4*s.*)

This is one of a series of pamphlets published by the A.E.S.D. and in it an attempt has been made to describe the technique of process planning, that is, the technical planning necessary to ensure the efficient production of an article, and the responsibilities of those engaged upon such work. Reference has been made to the inter-relation of planning with the work of other technicians, particularly the jig and tool draughtsman, time study engineer, and the estimator. The pamphlet is divided into chapters covering the approach, machining processes, press and sheet metal work, materials handling and plant layout.

Practical Metrology, Vol. 2. By K. J. HUME and G. H. SHARP. *Macdonald and Company (Publishers), Limited*, 16 *Maddox-street, London, W.*1. (7*s.* 6*d.*)

The second volume of the series of four, which are planned to provide collections of laboratory experiments in metrology, covers the measurement of plug gauges, plate gauges, spur gears, screw gauges and the method of taking a cast of a small ring screw gauge or similar shape. In all, 12 experiments are described, and in an appendix tables are given of the necessary calculations and corrections.

Jane's Fighting Ships, 1955–56. Edited by RAYMOND V. B. BLACKMAN. *Jane's Fighting Ships Publishing Company, Limited*, 25 *Gilbert-street, London, W.*1. (84*s.*)

The 57th edition of " Jane's Fighting Ships " includes more fresh material than is usual. There are 450 new illustrations, and the issue marks the completion of the conversion of all silhouette drawings to the uniform scale of 150 ft. to one inch. Particulars of H.M.S. Ark Royal are given and also some details of the two nuclear-powered submarines, the Nautilus and the Sea Wolf, launched by the United States. An interesting development is the large number of wooden warships recently constructed by the major Powers.

Naval Marine Engineering Practice. Formerly published as " Marine Engineering Notes for Engine Room Artificers' and Mechanicians' Training." *H.M. Stationery Office, Kingsway, London, W.C.*2. (25*s.*)

These notes have been compiled for the purpose of illustrating and describing the operation and maintenance of machinery for which the engine room department is responsible on H.M. ships. They are primarily, as the older title suggests, for the training of engine room artificers and mechanicians. The sketches and notes refer to typical machines most likely to be met with in the different classes of ships and are intended as a basic guide for the general principles. The contents include notes on boilers, reciprocating machinery, turbines, auxiliary machinery and internal combustion engines.

The New American Machinist's Handbook. Edited by RUPERT LE GRAND. Based upon earlier editions of " American Machinists' Handbook." *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (9 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (67*s.* 6*d.*)

The author states that the guiding principle in writing the handbook has been practicality of subject matter. The purpose has been to create an encyclopaedic treatment to serve both as a reference work and as a text-book to broaden the knowledge of the reader in many branches of metal working activity. It is divided into eleven main parts covering machine methods, metal forming, assembly, finishing, machine tool standards, and other practices. Each part is divided into sections covering specific items.

Basic Mathematics for Science and Engineering. By PAUL G. ANDRES, HUGH J. MISER and HAIM REINGOLD. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (6.75 dols); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (54*s.*)

For the intelligent pursuit of scientific and engineering courses a firm foundation in elementary mathematics, including algebra, trigonometry, analytical geometry and some calculus is necessary. The aim of this text-book is to provide that basis. The mathematical principles are illustrated with examples chosen from a wide variety of scientific and engineering fields, and attention is given to such topics as the degree of accuracy required or error permitted in a given computation, graphical methods, vector analysis, differential and integral calculus and the use of a slide rule. The book, which was prepared by the late Professor Andres of the Illinois Institute of Technology, Dr. Reingold of the same foundation and Dr. Miser of the United States Air Force, is a revised version of the text-book, " Basic Mathematics for Engineers," by the same authors published in 1944. There are a large number of worked examples, exercises with answers and diagrams, and an index.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

V-Rope Drives. R. AND J. DICK, LTD., Greenhead Works, Glasgow, S.E. " Dickrope " V-rope drives; these have an inner load-carrying core and an outer abrasion-resistant cover. Choice of size and number, range of sizes and types, and formulae for drive design. Also standard range of pulleys. Illustrated 30 page catalogue, with special quick-selection tables.

Pipework. AITON & CO. LTD., St. Stephen's House, Victoria-embankment, Westminster, London, S.W.1. Pipework and ancillary equipment (such as supports and expansion units) for power stations, oil refineries, industry generally and ship installation. Standard data on pipe sizes and design recommendations; quality and performance data. Illustrated catalogue.

Electric Convector Heaters. SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD., 38-39 Upper Thames-street, London, E.C.4. Convector heaters for domestic, industrial and commercial uses. Wall or floor mounting, five sizes from ½ to 2 kW; also thermostat for use in conjunction. Illustrated leaflet.

" Service for Engineers." JOHN S. YOUNG & CO. LTD., Maryville-avenue, Giffnock, Glasgow. The first number of a new house journal, to be published periodically. The firm are stockists of machine tools and also carry out special and general purpose fabrication of equipment.

Testing Materials. BALDWIN-LIMA-HAMILTON CORP., Philadelphia 42, Pa., U.S.A. Baldwin-Tate-Emery universal testing machines, with capacities of from 10,000 lb. to 5,000,000 lb. described; particular reference to hydraulic loading and weighing systems. Illustrated 12 page bulletin.

Grid Rollers. HYSTER CO., Tractor Equipment Division, Portland 8, Oregon. Grid rollers for the compaction of earth fills and for salvaging bituminous pavements. Gross weight of machines, 30,000 lb. Operational data. Illustrated broadsheets.

Hydraulic Loader. E. BOYDELL & CO. LTD. Old Trafford, Manchester, 16. Muir-Hill, model 2-WL, hydraulic loader fitted with general and special-purpose buckets. Brief specification and operational data. Illustrated booklet.

Air-Break Circuit-Breaker. THE BELMOS CO. LTD., Bellshill, Lanarkshire. Hand-operated air-break circuit-breaker rated at 600 amperes, 650 volts alternating current, for use in switchboards. Full technical details. Illustrated leaflet.

Turbo-Charged Two-Stroke Engines. FIAT, Turino, Italy. Medium and large two-stroke turbo-charged engines—their development and performance. Ranging from 450 to 750 mm. bore. Illustrated booklet.

Steel Fabrication. DORMAN LONG & CO. LTD., Zetland-road, Middlesbrough. Last year's activity of the company—in steel, engineering and chemicals—told in pictures, including notes on expansion at the company's own works. Illustrated booklet.

Valve Makers. COCKBURNS LTD., Cardonald, Glasgow, S.W.1. History and organisation of the firm, with lists of agents and licencees. Illustrated folder.

Continuous Furnaces. GIBBONS BROTHERS, LTD., Dibdale, Dudley, Worcestershire. " Thermo " continuous furnaces for billets, blooms, ingots and slabs. Illustrated leaflet. S.

Domestic Gas Appliances. THE GAS COUNCIL, 1, Grosvenor-place, London, S.W.1. List of tested and approved domestic gas appliances, issue No. 4, dated December, 1955.

Fast Battery Charger. CRYPTON EQUIPMENT, LTD., Bridgwater, Somerset. Details of equipment for the rapid charging of batteries, including some recent improvements. Illustrated leaflet.

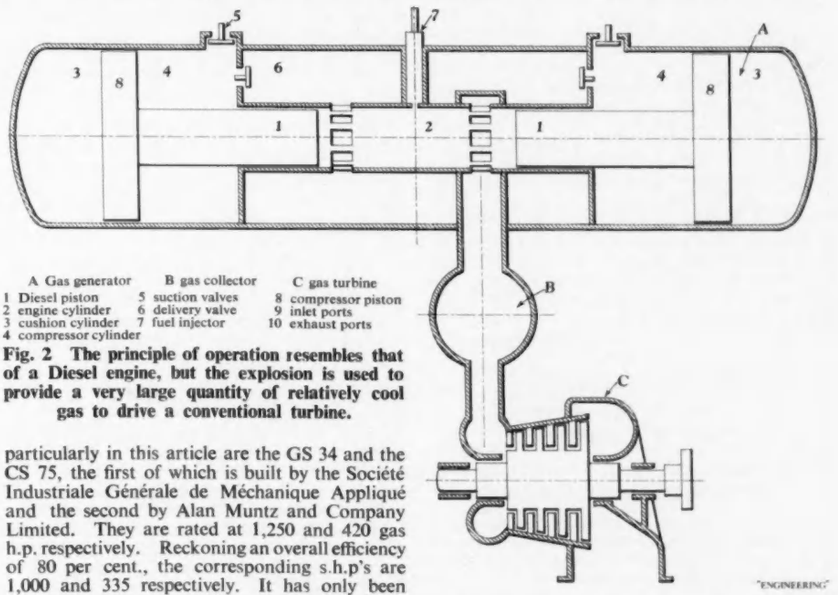
THE FREE PISTON GAS GENERATOR

COMBINING THE BEST OF GAS TURBINES AND DIESEL ENGINES

Most of the development work which has made the free-piston gas generator into a commercial proposition has taken place in France during the post-war period. This article is based on three papers given recently by R. Huber, J. J. McMullen, and E. S. L. Beale and P. Watson, which have given a picture of the present state of development, and present and future applications.*

The purpose of the free-piston gas generator, which is associated with the name of Count Pescara, is implied by its name. It is a machine designed to produce large quantities of gas at moderate pressures and temperatures which can then be used to drive a turbine. The principle is illustrated in Fig. 2, which shows one of the more usual types. Fuel is exploded in the engine cylinder (2 on the diagram) which causes the two pistons to move outwards and compress the air behind them. When the exhaust ports are uncovered by the movement of the piston the burnt gases pass into the receiver (B). This reduces the pressure in (2) and the pistons are returned by the compressed air in the cushion cylinders (3). During the inward movement, the air in cylinders (4) is compressed into the engine case and enters the inlet ports, scavenging and supercharging the engine cylinder. Fuel is again injected and exploded when the cycle is then repeated. Thus the output from the machine consists of the products of combustion diluted and cooled by the excess scavenge air. The two pistons are synchronised by a light linkage which is utilised to operate the fuel-injection pump but not to transmit any power. The cylinder is highly supercharged since the delivery pressure at full load is normally in excess of 45 lb. per sq. in. gauge and this is the back pressure on the engine cylinder. Historically, it may be said that the development of the gas generator started with Doctor Buchi, who took out a French patent in 1905. The first machine of the modern form is believed to have been built by Pescara and run in 1925, since when the development has been proceeding in France at the Société d'Etudes Mécaniques et Energétiques. Models have also been made in the United States and this country, but development has not been so extensive.

The inward compressing type as shown in Fig. 2 is one that has been favoured by the French developments. The two sizes considered particularly in this article are the GS 34 and the CS 75, the first of which is built by the Société Industriale Générale de Méchanique Appliqué and the second by Alan Muntz and Company Limited. They are rated at 1,250 and 420 gas h.p. respectively. Reckoning an overall efficiency of 80 per cent., the corresponding s.h.p's are 1,000 and 335 respectively. It has only been found necessary in practice to employ a single set of synchronising rods instead of a symmetrical pair, and they can either take the form of a rack and pinion design, one rod from each piston meshing with opposite sides of the pinion as in the CS 75, or a lazy-tongs type of linkage as is used on the GS 34. Alternatively a rocking lever and contact rod-arrangement can be used.



A Gas generator
1 Diesel piston
2 engine cylinder
3 cushion cylinder
4 compressor cylinder

B gas collector
5 suction valves
6 delivery valve
7 fuel injector

C gas turbine
8 compressor piston
9 inlet ports
10 exhaust ports

Fig. 2 The principle of operation resembles that of a Diesel engine, but the explosion is used to provide a very large quantity of relatively cool gas to drive a conventional turbine.

As already mentioned, since it is not theoretically required to transmit any load other than the drive to the fuel-injection pump, the synchronising mechanism can be very light. The symmetrical construction of the engines renders them very insensitive to thermal distortion due to change in load, and it is considered that they can be started from cold and brought up to full power within two minutes, without running any risks. The reciprocating parts are balanced and there is therefore no mechanical vibration from them, but there is a certain amount of vibration caused by the inertia of the exhaust gases which must be considered during design. The pulsations can be reduced by using large chambers both on the intake and delivery of the generator.

The purpose of the gas collector (B in Fig. 2) is to smooth out the impulsive discharge which occurs when the ports are opened, and to allow a rapid blow-down of the pressure in the Diesel cylinder. This collector is at that moment of the order of 10 times the volume of the engine cylinder but it may be possible to reduce this in later designs. The frequencies of the gas pulses are low enough not to constitute a risk to the turbine blades, which even in the first stage of a large turbine have a natural frequency of the order of 1,000 cycles, as the fundamental frequencies of the main pressure waves in the gas are approximately 10 cycles per second with the GS 34 and 18 with the CS 75. The turbine itself acts as an exhaust silencer and the general noise produced by a free-piston engine is roughly comparable to that of a Diesel engine running at the same speed, but lacks the high-frequency components such as valve clatter.

The cooling arrangements consist simply of a stationary tube which projects into the "piston rod" and throws a jet of cold oil on to the underside of the piston crown. Maintenance and assembly is simple in both sizes.

CONTROL

The power output is controlled by varying the stroke, thereby altering the main flow of gas. In the usual arrangement, with the gas generator supplying a turbine, an increase in gas flow results, in turn, in an increase in delivery pressure, and at the same time a rise in delivery temperature. Thus, the combined effect is that a small change of stroke causes a large change of power; for example, a drop in power from 100 per cent. to 25 per cent. is produced by a reduction in stroke of about 20 per cent. only. This effect is enhanced by the relatively high clearance volume of the compressor cylinder, which means that the percentage change in the delivery is greater than the percentage change in the length of the stroke. The clearance volume is made up partly of the fixed volume in the suction and delivery valves, representing about 4 per cent. of full load stroke, and partly of the clearance between the compressor piston face and the cylinder head at the inner dead point, which is about 5 per cent. of the stroke, giving a combined figure of between 9 and 10 per cent. at full load.

The I.D.P. is fixed by the pressure in the cushion cylinder, and this is maintained at the required value by the automatic cushion air control or stabiliser which can be given the required characteristics depending on the delivery pressure of the gas and on the outer dead point. The range of gas delivery is, in fact, rather

* R. Huber, "Les Groupes Électrogènes à Turbines à Gaz Alimentées par Générateurs à Pistons Libres," Schweizerische Bauzeitung, Nos. 44/45, 1954; J. J. McMullen, "A Free Piston Propulsion Plant for a Liberty Ship," A.S.M.E. Paper No. 55/OGP, June 14, 1955. E. S. L. Beale and P. Watson, "Free Piston Gas Generators and Their Applications," paper presented to the Diesel Engineers and Users Association on January 19, 1956.

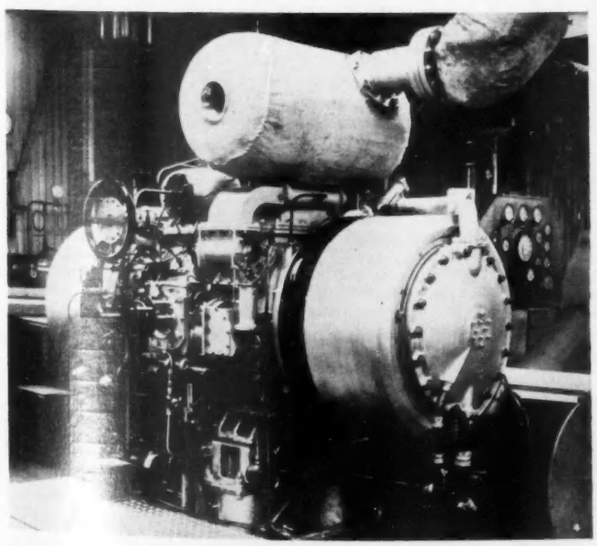


Fig. 1 ... gas-generator may be said to take the place of the combustion ... er and turbo-compressor of a gas turbine, but with a higher efficien... The model shown on test is rated at 420 gas horse power.

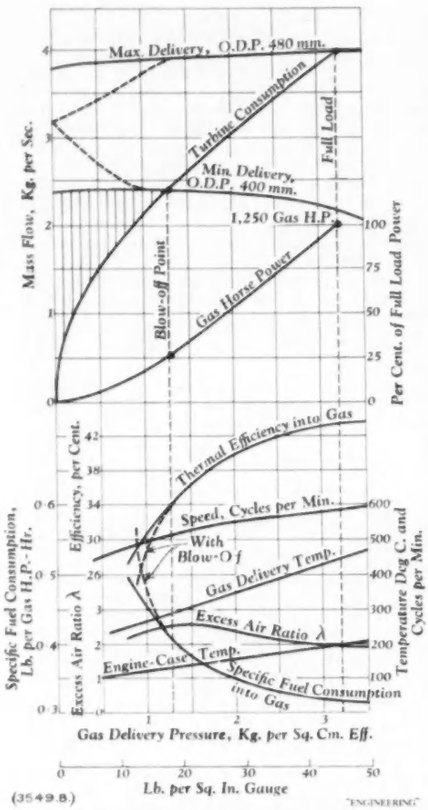


Fig. 3 Performance curves for GS 34 machine, based on gas delivery pressure.

restricted, as the stroke variation is limited by the position of the ports. Consequently, in order to reduce the power of the turbine below that determined by the minimum delivery of the generator, a blow-off valve must be included to allow the excess gas to escape. This occurs at something less than 30 per cent. of full output power. The fuel for combustion is injected by a simple form of accumulator pump, the quantity being metered by a plunger driven mechanically during the instroke of the pistons. Until the next injection occurs the fuel is stored in a cylinder, the plunger of which is loaded to the required pressure by compressed air acting on a larger piston. Injection starts just before I.D.P. with the mechanical opening of a poppet-type timing valve which opens the connection to the injectors, and injection then proceeds independently of any motion of the moving parts of the engine. Conventional multi-hole nozzles are used.

On the GS 34, four injectors feed direct into the cylinder and two supply about 5 per cent. of the total fuel to small pre-combustion chambers. Four direct injectors are used on the CS 75. Combustion conditions are favourable, and residual fuels can be used successfully on the GS 34; present tests indicate that this applies also to the CS 75.

Indicated mean effective pressure at full load is about 180 lb. per sq. in., and main piston speeds are of the order of 1,600 ft. per min. The average temperature of the top piston ring is 180 deg. C. The compression ratio in the Diesel cylinder at full load is about 9 to 1, with a gas delivery pressure of 45 to 50 lb. per sq. in. Under these conditions the maximum cylinder pressure is about 1,700 lb. per sq. in. The gas delivery temperature depends on delivery pressure and reaches between 440 and 480 deg. C. at full load for an ambient temperature of 15 deg. C. As both temperature and pressure are moderate, the design of the turbine presents no particular difficulties. There is no corrosion trouble from vanadium because the temperature is far too low, and ferritic steels can be used which are both cheaper and easier to machine than the special alloys required for the high temperatures met with in the conventional gas turbine. As a result smaller tip and gland clearances can safely be employed. A conversion efficiency of 88 per cent. has been obtained in a 2,000 s.h.p. turbine.

Regarding the individual controls for each gas generator, the first is that for the stabiliser which maintains the correct pressure in the cushion cylinder to give the required energy to the pistons; this usually consists of a slide valve, controlled by a differential piston and a spring, balancing the cushion pressure against the engine case pressure. The natural means of altering the power output is by control of the quantity of fuel injected; this has both an upper and lower limit, the latter being necessary to give a sufficient stroke to open the scavenge ports adequately; a cam device controlled by the delivery pressure can be used to govern this. The fuel-injection timing has to be altered to suit the position of I.D.P. and can be controlled by the gas-delivery pressure.

Starting is effected by first manoeuvring the pistons to approximately the O.D.P. by means of a small air-operated piston, then suddenly discharging compressed air into the cushion cylinders. This throws the pistons together at full speed on the first stroke. Stopping is effected simply by cutting off the fuel. When a generator is used in conjunction with a turbine, overall controls are required which are governed from the turbine output.

One of the characteristics which has to be taken into account when installing this equipment is that, while the output power can be reduced very rapidly by means of the gas-control valve, it cannot be increased as quickly. There are substantial volumes of gas in the engine case, the gas collector and the connecting pipe, which have to be pumped to the higher pressure and this takes several strokes. Also, in order to be able to run at the higher delivery pressure the cushion pressure must be increased, which takes a matter of seconds. The speed of response is adequate for marine, locomotive, pump and similar appliances, but for generating sets a flywheel is needed if a very small temporary drop in speed is required on sudden application of full load; flywheels, however, are not normally needed.

PERFORMANCE

The thermal efficiencies of the GS 34 generator are shown in Fig. 3 together with other performance figures. When plotted on a base of power output the specific consumption shows some improvement because a scavenge-air bypass valve is used to avoid an unnecessary amount of air being passed through the Diesel cylinder. These curves are shown in Fig. 4 for a CS 75 generator. For comparison, overall performance figures for a 1·5 MW generating set are shown in Fig. 5.

Reckoned on a s.h.p. basis an overall efficiency for a 2,000 h.p. generating set can be taken to be 36 per cent., this is approximately 0·386 lb. of fuel per s.h.p. hour using an oil of 10,150 C.H.U. per lb. These figures are not as good as those given by many Diesel engines but it is expected that future development will improve them. One advantage is that the gas generator is better suited to burn residual fuels than the conventional Diesel engine.

INSTALLATION

No heavy foundations are required for a gas generator set as mechanical vibrations are very slight; also there are no alignment problems as the only connection between the generator and turbine is the pipe, which may be flexible, or fitted with flexible couplings. It is quite possible to use several gas generators to supply a single turbine, and this has been done in some of the existing installations. Low-pressure steam pipes are suitable for connecting the turbine and generator provided they are of material that will resist creep. Allowance must be made for expansion in the pipe work.

The gas generators can be mounted in any convenient arrangement around the turbine and, if necessary, where floor space is limited, can be placed one on top of another. In the 6 MW set installed at Cherbourg, eight generators are used to feed one turbine. With this arrangement of several units feeding a common supply one or more of them can be stopped for maintenance work or when reduced power is required, without causing any difficulties. In a simple gas-generator set the gas is exhausted from the turbine when running at full load at a temperature of about 260 deg. C. This can usefully be employed in an exhaust-heat boiler producing steam at pressures up to about 100 lb. per sq. in. with a reasonable amount of transfer surface in the boiler. Without burning any additional fuel, something over 1 lb. of steam per hour can be raised per s.h.p. when the turbine is running at full load. It is equally possible to fit an additional burner to the boiler if more steam is required.

As regards frequency of inspection and maintenance requirements, experience has shown that the turbine can run satisfactorily for between 20,000 and 25,000 hours without overhaul. Some of the gas-generator parts still require fairly frequent inspection; those most needing it are the pre-combustion chamber and the moving parts, which have to be examined every 1,500 hours at the moment, but this period is now being increased to 3,000 hours, due to improved designs. After this latter period, the lubrication, cooling circuits and the clearances in the synchronising mechanism should also be checked. In the

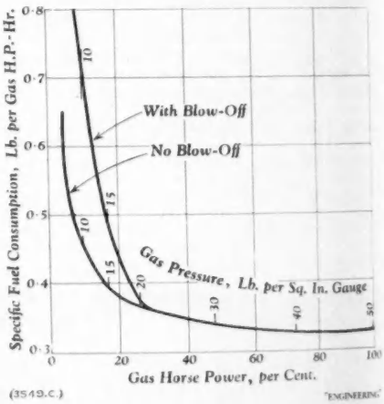


Fig. 4 Fuel consumption curves for CS 75 machine.

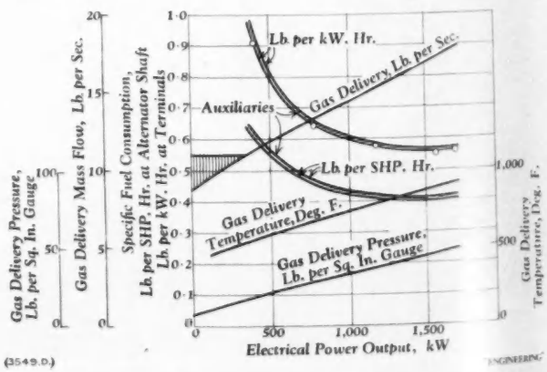

Lb. per kW. Hr.
Gas Delivery, Lb. per Sec.
Auxiliaries
Lb. per SHP. Hr.
Gas Delivery Temperature, Deg. F.
Gas Delivery Pressure, Lb. per Sq. In. Gauge
Gas Delivery Pressure, Lb. per Sq. In. Gauge
Gas Delivery Mass Flow, Lb. per Sec.
Specific Fuel Consumption, Lb. per SHP. Hr. at Alternator Shaft
Lb. per kW. Hr. at Terminals
Gas Delivery Temperature, Deg. F.
Electrical Power Output, kW
(3549.D.)
"ENGINEERING"

Fig. 5 Operational characteristics for a complete 1,500 kW generating plant using two GS 34 free-piston gas generators

near future it is expected that maintenance work need only be carried out at 6,000 hour intervals, apart from visual inspection of the injectors which still will have to be undertaken after every 1,500 hours.

APPLICATIONS

The first gas-generator set to be installed was a 700 kW unit in Southern Tunisia; this has now run for over 15,000 hours, working 24 hours a day with a stop of eight hours per week for maintenance, when the whole of the plant that it supplies is also shut down. It has been running on a fuel oil of a viscosity of approximately 950 seconds Redwood I. An inspection was carried out on the turbine at the end of 12,000 hours running, and the blades and bearings were found to be in excellent condition, the light deposit on the blades being easily removed. At this time the instrument readings showed no deterioration in performance. Several other generating sets have been installed, the largest of which is the 6 MW plant at Cherbourg already mentioned. This has now been in regular operation for some time, running 14 hours a day, and no difficulties have been experienced either in starting up, in coming off load or during the actual running. The turbines used in the different sets installed have not all been made by the same firm.

In the field of rail traction an experimental 1,000 h.p. locomotive has been made by the Regie Nationale des Usines Renault: a single GS 34 generator feeds a six-stage turbine which has a mechanical drive to the axles. The locomotive has a BoBo wheel arrangement. There are two gear ratios in the transmission, which can be changed while running. A light furnace oil has been used with a viscosity of about 85 seconds Redwood I at 100 deg. C., which is considerably cheaper than Diesel oil; this off-sets the slightly lower efficiency as compared with a Diesel locomotive. The "Turbo-Diesel" has successfully run for over 125,000 miles on regular passenger service and larger models, one of 2,000 and the other of 2,400 h.p. have been proposed for construction.

The application of the gas generator to road transport will probably be limited to heavy vehicles only, on account of size.*

SHIP PROPULSION

Sets have been installed in the two coasting vessels "Cantenac" and "Merignac" both of about 850 tons, the first of which went into operation in February, 1954, and the second in August of the same year. Power is supplied by two GS 34 generators and turbines geared to a single screw. Both vessels have been in continuous service except for inspection periods and have given no trouble; they are particularly well behaved in bad weather as, even if the propellor comes part clear of the sea, the only parts of the main engine subject to variation in speed are the turbine and reduction gear. No adjustment of the oil and cooling-water systems is necessary. During the first year's service of the Cantenac, trouble in the main engines held up the ship on two occasions only and each of these was only of two days' duration. Other French vessels fitted with this form of propulsion gear include 21 minesweepers, the first of which was the "Sirius" commissioned in 1952. Eighteen are now in commission and the remaining three are going into service. In America, four Liberty ships are being converted for propulsion by gas generators with turbines, there being various differences in the method to try out the effects. In these vessels the old reciprocating engine had an indicated horse-power of 2,500 and weighed 463·8 tons including the boilers and auxiliaries; the new free piston plant will weigh only 385·4 tons and will increase the s.h.p. to 6,000. The estimated fuel consumption will be reduced from 0·65 to 0·532 barrels per mile based on residual fuel.

It has been said that the present state of the free-piston engine corresponds to that of the Diesel engine about 25 years ago and further developments will proceed, increasing the reliability and reducing the cost of operation. Other sizes of gas generator will also be put into production in due course.

* Since these papers were presented, General Motors have announced that they have installed a set in a private car.

Institute of Metals Spring Meeting (*concluded from page* 310)

METAL SINTERING AND FRACTURE

To end our report of the spring meeting of the Institute of Metals, held in London from April 10 to 13, we now deal with the concluding technical sessions of the meeting.

POWDER METALLURGY

On the morning of Thursday, April 12, the programme was divided into two parts, the second of which comprised the consideration of six papers, the first three on "Powder Metallurgy," and the last three on "Embrittlement and Fracture."

Of the three papers on powder metallurgy, which were introduced by Dr. J. C. Chaston acting as *rapporteur*, the first was upon "Porosity and Permeability Changes During the Sintering of Copper Powder." It was by Mr. G. Arthur, of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, Berkshire, who stated that the pores in a sintered specimen could be divided into two categories, firstly, pores connected to the surface of the specimen, called interconnected pores and, secondly, closed pores bounded on all sides by solid material. The main aim of the present work had been to investigate how the relative proportions of closed and interconnected pores varied during sintering and to study the relationship, if any, between permeability and interconnected porosity. The experiments had been made on copper powders sintered in hydrogen for periods of up to 8 hours at 1,000 deg. C. The effects of particle shape and size had been investigated by using electrolytic (angular) and atomised (spherical) powders in the size ranges − 240 + 300 and − 300 mesh. It had been found that in both loose-sintered and pre-compacted specimens the porosity was mainly interconnected for most of the sintering process.

During sintering the closed porosity (about 2 per cent.) remained practically constant, while the interconnected porosity decreased. It was therefore proposed that surface diffusion was possibly operative. At approximately 6 per cent. total porosity, the interconnected porosity was zero and the closed porosity was a maximum. The permeability, λ, of the loose-sintered specimens decreased with decreasing porosity but was still measurable at porosities of 10 per cent. With cold-compacted specimens the permeability decreased with increasing compacting pressure. On sintered compacted specimens the permeability at first increased and then decreased with decreasing porosity.

SINTERING THORIUM

The second paper was concerned with "The Sintering, Fabrication, and Properties of Thorium"; it was by Mr. M. D. Smith and Professor R. W. K. Honeycombe, of the Department of Metallurgy, University of Sheffield. The authors stated that they had studied the powder metallurgy of thorium over a range of compacting pressures and sintering temperatures. The optimum conditions had been obtained by pressing at 22·5 tons per sq. in., and then sintering in high vacuum for 2 hours at 1,300 deg. C. Metal of density approaching the theoretical had been obtained by re-sintering after cold rolling to 50 per cent. reduction of thickness. Re-sintered metal, though having an average oxide content of 1·75 wt. per cent., was still very ductile. Rolling was a very feasible method of fabrication, but other methods, such as wire-drawing, might present a problem in lubrication. Similar considerations might well apply to other forming and shaping operations.

The third paper, namely, "The Manufacture and Properties of High-Strength Nickel-Tungsten Alloys," was by Dr. M. Davis and Mr. C. E. Densem, of the Services Electronics Research Laboratory (Admiralty), Baldock, Hertfordshire, and Mr. J. H. Rendall, of the Metallurgy Division, National Physical Laboratory, Teddington. The authors stated that they had prepared nickel-tungsten alloys containing from 5 to 40 wt. per cent. tungsten by powder metallurgy and had successfully cold-worked them into fine-gauge wire and strip, suitable for thermionic-valve construction. The strength of the alloys increased with the tungsten content, and high-temperature age-hardening was exhibited by alloys containing over 30 wt. per cent. of tungsten. Most requirements, however, would be met by alloys containing up to 30 per cent. tungsten, and these were more readily manufactured than age-hardening alloys.

EMBRITTLEMENT AND FRACTURE

The remainder of the morning was devoted to the presentation of three papers having as their common theme "Embrittlement and Fracture." They were introduced by Dr. W. A. Baker, acting as *rapporteur*. All the papers were communications from the British Non-Ferrous Metals Research Association.

The first paper was entitled "Intercrystalline Fracture of Beta-Brasses Containing Aluminium" and was by Mr. E. C. W. Perryman. He stated that earlier work had shown that cast β-brasses containing 3 per cent. or more of aluminium were susceptible to delayed intercrystalline fracture when loaded in sodium chloride solution, in air, or in inert liquids. A possible explanation was that relaxation of shear stress along appropriately oriented grain boundaries resulted in the establishment of stress concentrations at other boundaries with the consequent formation of intercrystalline cracks.

The present work had shown that intergranular failures occurring in binary and ternary β-brasses were probably due to a mechanism of this kind and, moreover, had provided evidence that the effects of aluminium might be exercised, at least in part, through some modification of the grain-boundary structures.

The second paper dealt with "The Effect of Zirconium and Titanium on the Intercrystalline-Cracking Tendency of Beta Brasses" and was by Mr. Perryman and Mr. R. J. Goodwin. They stated that the addition of suitably-chosen elements of high melting point might be expected to increase the resistance of the grain boundaries to the relaxation of shear stress, and thereby decrease the liability of these materials to intergranular fracture. Small additions of zirconium and titanium had been made to β-brasses of three compositions, containing, respectively, 0·1 per cent. of aluminium; 4 per cent. of aluminium; and 5 per cent. of aluminium, 1·5 per cent. of iron and 1·5 per cent. of manganese. The results of sustained tensile tests on as-cast 4 per cent. aluminium β-brasses had shown that both 0·05 per cent. of titanium and 0·05 per cent. of zirconium increased the time to fracture, zirconium appearing to be more effective than titanium. Tests on aluminium β-brasses containing iron and manganese had shown that the presence of the two last-named elements increased the resistance to delayed fracture. In these complex alloys the zirconium and titanium additions had an adverse effect on their resistance to this type of failure.

The third paper was by Mr. R. Eborall and Mr. P. Gregory. It dealt with "The Mechanism of Embrittlement by a Liquid Phase." The authors stated that liquid lead had been found to cause considerable embrittlement,

with grain-boundary failures, both in β-brass and in tin bronze, although it did not spread round the boundaries in the absence of stress. Failure was accompanied by the spreading of the liquid among the cracks. According to the theory of cracking, put forward in 1920 by A. A. Griffith, the stress needed to make a given crack grow depended upon the surface energy required, and this might be greatly reduced if the tip of the crack were filled with the liquid phase.

ROLLING TEXTURES AND RECRYSTALLISATION

On Thursday, afternoon, April 12, the programme included four papers on the theme "Rolling Textures and Recrystallisation," were presented by Dr. T. Ll. Richards as *rapporteur*.

The first of these four papers was entitled "Surface Nucleation in the Recrystallisation of Aluminium Single Crystals," and was by Mr. C. D. Graham and Professor R. Maddin. The authors described experiments carried out at the University of Birmingham and stated that recrystallisation nuclei in extended aluminium single crystals had been found to be preferentially in a surface layer about $2 \cdot 5$ to 5×10^{-3} cm. deep. The experiments suggested that when a single crystal of aluminium was pulled in air, the distribution of dislocations at the surface was not the same as in the interior of the crystal. This afforded further evidence that the surface appearance of deformed crystals might not be representative of the conditions of the material below the surface.

The second paper, on "Deformation and Annealing Textures in Thorium," was by Dr. R. E. Smallman, of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, Berkshire. He stated that the potentialities of thorium as a reactor material had prompted an investigation of its physical properties, particularly its alloying and deformation characteristics. Most of the present research had been carried out on sintered thorium bar, containing 99·5 per cent. total thorium, with calcium 215, iron 55, nitrogen 195, and other elements less than 10 parts per million. For compression rolling the texture of thorium was similar to that developed in copper, but markedly different from that of 70 : 30 brass.

Further work by Mr. Smallman was reported in the third paper which was entitled "Textures in Face-Centred Cubic Metals and Alloys." He stated that using quantitative methods, the rolling texture had been determined for all the common face-centred cubic metals, namely, copper, aluminium, nickel, gold, silver and thorium, and selected alloys based on these pure metals. Alloys had been chosen which might reasonably be expected to show yield behaviour, and the variation in texture with composition and temperature had been examined in them.

The fourth and last paper was "On the Recrystallisation of Cold-Rolled Commercially Pure Titanium," and was by Professor I. Obinata and Mr. K. Nishimura and dealt with work carried out in Tohoku University, Sendai, Japan. The authors stated that they had made a general study, principally by microscopic means, of the recrystallisation of cold-rolled commercially pure titanium. Two types of recrystallisation had been found to take place simultaneously; one not involving nucleation and the other proceeding by the ordinary nucleation-and-growth mechanism. A notable feature was the lack of uniformity, both in the progress of recrystallisation and in the gram size immediately after recrystallisation was complete.

The two final technical sessions of the meeting, held on the morning and afternoon of Friday, April 13, had been arranged by the Metal Physics Committee of the Institute. The morning session was devoted to an informal discussion on the theme "Alloy Thermodynamics" while, in the afternoon, a lecture on "Electron Emission from Metals" was delivered by Professor Dr. Erich Schmid of the University of Vienna.

UNLOADING A WAGON BY OSCILLATION

INDUCED CONVEYING MOTION

Designed for the rapid unloading of grain, chemicals and other bulk free-flowing materials from box-cars, the "Kar-flo" unloader, made by the Link-Belt Company, Chicago, Ill., U.S.A., operates by oscillating the car to effect a conveying motion. The equipment consists of a heavy steel platform carrying the running rails and designed for through passage of shunting engines and loaded wagons, hydraulic clamping gear to centre and hold the wagon in position, and oscillating gear mounted beneath the platform. A control panel is provided at a point a little offset from the centre of the platform, and the running rail remote from the control point is raised so that the wagon is tilted towards the operator and the hopper entry-point between the control panel and the inner running rail.

In operation a wagon is brought on to the platform of the unloader and left approximately in the centre. The operator then starts the hydraulic clamping gear by means of a valve on the control panel, and clamps rise from below rail level at each end of the platform, centre the wagon, and hold it by pressure against the two end couplers. The wagon door on the discharge side is then opened, hydraulic platform locks are released by the operator, and the oscillating gear motor is started by push-button. This gear consists of counterweights rotating in opposite directions to produce a reciprocating force. It is mounted beneath the platform, and as the latter is now freed from its hydraulic locks and is carried at each end on rocker arms and heavy coil springs, a rocking motion results.

MATERIAL FLOWS TOWARDS CENTRE OF WAGON

The natural frequency of the springs amplifies the rocking motion, and there is a movement of the platform of about 3 in. at each end, the speed being 140 strokes per minute. The effect on the material in the wagon is the same as that of a shaker conveyor, and there is a steady flow to the centre of the wagon. As the wagon door is open, and the wagon is tilted towards the discharge point, material flows out and passes through a gridded aperture in the floor to an underground hopper.

The unloader is heavily constructed, but the power requirements are relatively low, 25 h.p. being needed for the main drive and 15 h.p. for the hydraulic pumps. Control is by one man, the control panel being provided with interlocks to prevent wrong-sequence operation. The main drive cannot be started when the platform locks are in position, or when the wagon clamps are disengaged. There are two hydraulic pumps. One, operating at 200 lb. per sq. in., provides the power for rapid movement of the wagon clamps; the other, working at 1,200 lb. per sq. in., gives the squeeze pressure for holding the wagon with the clamps, and also operates the platform locks. The unloader is designed to accommodate wagons weighing up to 150,000 lb. loaded, and to deal with four vehicles an hour.

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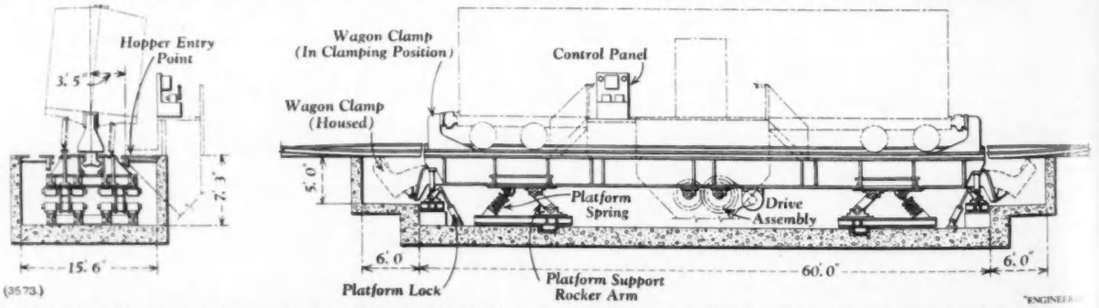
HIGH ASPECT RATIO AEROVAN

At the Paris Salon last year, Avions Hurel Dubois announced that they were collaborating with F. G. Miles Limited, Shoreham, Sussex, to fit a Hurel Dubois high aspect ratio wing on the Miles Aerovan freighter aircraft with the object of improving its take-off performance, particularly with one engine out of action. F. G. Miles, Limited, have recently announced that construction of the H.D.M. 105, as the modified aircraft is known, is well advanced, and it is expected to fly this summer.

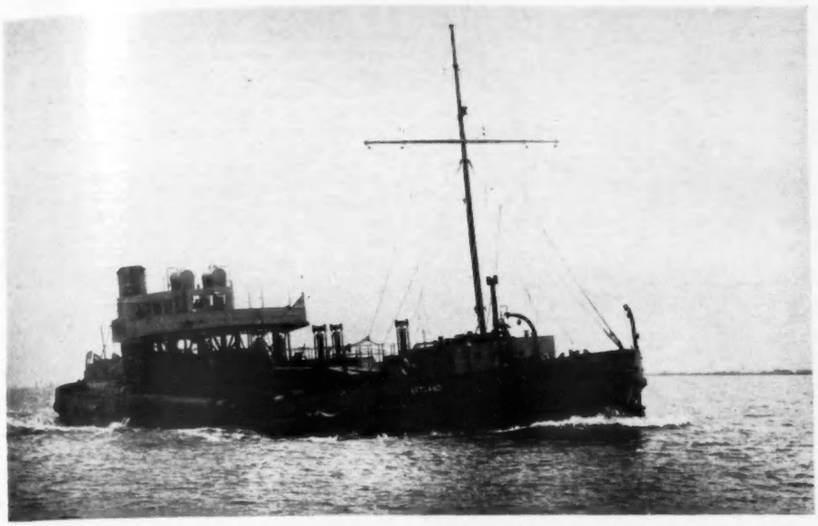
The original box-type fuselage, tail booms and tail surfaces of the Aerovan—constructed shortly after the second World War—have been retained except for the outboard fins and rudder which have been doubled in size. The new wing, of metal construction, has an aspect ratio of 21 whereas the original wing has an aspect ratio of 6·4. Since the object of the exercise is to see how the change of wing improves the performance, the original two Cirrus Major III engines, each developing 150 h.p., are being retained.

One of the main features of the Hurel Dubois high aspect ratio layout is the use of lifting struts and a stub wing. This enables the undercarriage main units to be installed at the outboard end of the stub wing, directly below the engines, thus considerably widening the track and improving ground handling.

If the modification proves successful, the company may go forward with an all-metal development of the HDM 105, with increased power, possibly using de Havilland Gipsy Major 200 or Gipsy Queen engines.



An oscillating motion given to a railway wagon standing on the platform of a Link-Belt unloader causes bulk material to flow towards the wagon door and so to be discharged. The unloader can deal with for wagons, each weighing up to 150,000 lb. loaded, per hour.



The suction hopper dredge "Astland," owned by the Preston Authority, proceeding to sea in the loaded condition.

FROM RIVER BOTTOM TO SEA BED

DREDGING AT SOME PRINCIPAL BRITISH PORTS

When taking office as Chairman of the Scottish Section of the Institute of Marine Engineers, Mr. D. W. Low, of Messrs. Lobnitz and Company, Renfrew, reviewed the dredging operations undertaken during the last five years by a number of port authorities. This part of his remarks is given below; the remainder of his address, which was illustrated by films and slides, described a number of dredges that are in current use, two of which are illustrated on this page, and drew attention to the features that made each vessel suitable for the work on which it is engaged.

Without dredging and the removal of spoil from the waterways of the world, many ports would cease to function. This in turn would stifle sea-borne trade and all that that means to shipowners, shipbuilders, marine engineers and a host of other interests. To demonstrate this point a schedule (set out in Table I on page 376) has been prepared which lists the amounts of dredged spoil removed during the last five years by some British authorities.

FROM THE MERSEY

The Mersey Docks and Harbour Board operate a fleet of about 30 dredges and ancillary craft, constantly dredging and carrying sand and silt from the sea channels, river and docks. The problem of keeping the Mersey open to navigation against the forces of nature is immense and of this clear evidence exists in the average annual rate of spoil removal. The present fleet includes:—

3 Suction Hopper Dredges
6 Grab Hopper Dredges
4 Multi-Bucket Dredges and
12 Hopper Barges.

These vessels are on constant week-day and night service and are frequently employed on week-end duty, all as part of the port service to shipping.

In order to maintain the navigable channels in the Mersey area some 10,500,000 tons of sand are dredged and deposited at sea every year. This work is effected by self-propelled suction hopper dredges, one of which has the very large hopper capacity of 10,000 tons, regularly filled with sand from the sea channels by the dredging pumps in approximately two hours. Two other vessels of similar type can each carry a cargo of 5,000 tons in their hoppers.

At the entrances to and within the dock system the problem of siltation is severe and to meet this service, self-propelled grab hopper dredges are used. In this type of vessel single or multiple-grab cranes raise dock silt and mud from the bottom by grab bucket and discharge into the hopper. With a full hopper each vessel proceeds to sea under its own power to release the cargo. A fine system of operation has been developed, based on the principle that docks must be maintained at required depth without interference to shipping and the loss of revenue-earning berthing space.

The multi-bucket dredges are used mainly for maintenance work at the river entrances and at certain jetties. They are also employed on capital dredging, sometimes for prolonged periods, as the need for such work arises. These dredges are not equipped with hoppers and discharge the dredged spoil into hopper barges for transit to deposit ground. About eight units of the hopper barge fleet serve the bucket dredges while the remainder is employed on the carriage of quarried stone which is deposited on the revetments of the sea channels.

On the Thames the major part of the maintenance dredging consists of mud, but small amounts of clay, sand and ballast are encountered. There is the usual continuing fight against siltation. This problem is under constant investigation in order to devise more economical methods of removal and to reduce, by scientific means, the quantities to be removed. All dredging is accomplished by multi-bucket dredges in association with hopper barges, and by grab hopper dredges. The hopper barges are required to make a long passage to and from the dumping ground but the grab hopper dredges deposit their cargoes within the limits of the Authority at distances between 20 and 8 miles from the dredging positions. Experiments with suction dredging have so far been inconclusive, but this method may yet prove to be the economic answer to maintenance dredging in this great river where conditions would appear to offer scope for its adoption.

NORTH EAST COAST

About two thirds of the annual tonnage quoted for the Tees Conservancy was carried to a deposit ground at sea in self-propelled craft. The remainder of the output was pumped from barges to a reclamation area within the limits of the Authority. For the most part the work on this river is performed by multi-bucket dredges and grab dredges in association with hopper barges. The Authority, however, operates one self-propelled suction hopper dredge which in recent years has contributed greatly to improved maintenance dredging in the sands of the sea channels. Experimental work is proceeding on the handling of up-river silt with encouraging results.

The Clyde Navigation Trust operates a dredging fleet of:—

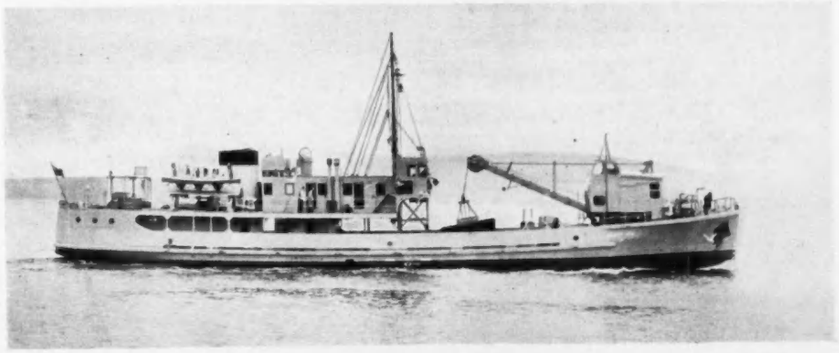
4 Grab Hopper Dredges
4 Multi-Bucket Dredges and
13 Hopper Barges.

No suction dredging is employed but amongst the ancillary craft is a diving bell barge adapted for sub-aqueous rockbreaking by means of explosives, a system whereby rock is pulverised under water for elevation to hopper barges by bucket dredging. A 15 ton rock cutting chisel is presently being added to the equipment of this vessel to enable rockbreaking to be carried out by percussion as well as by blasting. The dredging craft are employed almost exclusively on maintenance dredging, the multi-bucket dredges being used in the navigable channel of the river and in the dock areas, and the grab dredges alongside the quays and wharves on the riverside and in the docks.

On the Ribble a fleet of self-propelled suction hopper dredges is in service and until 1952, seven dredges of this type were working. The slight drop in spoil output for 1953 and 1954 was caused by a reduction in the operating fleet to four post-war dredges. Maintaining the river by dredging such large quantities each year imposes an onerous charge on the Port of Preston but there is little doubt that the cheapest method is employed to suit the circumstances. In addition the Authority operates grab dredges and hopper barges for dock service and for carrying stone to the training walls of the river.

HOPPER TYPES

At this stage, and simply as a matter of record, mention should be made of another



A Diesel-electric grab dredge, owned by the Mersey Docks and Harbour Board, photographed during trials on the Clyde.

TABLE I.—Quantities of Spoil in Tons Removed by Dredging from Sea Channels, Rivers and Docks

Year	1950	1951	1952	1953	1954
Authority, Mersey Docks and Harbour Board					
By multi-bucket dredge	989,382	826,335	775,550	654,650	785,180
By grab bucket dredge	1,731,777	2,020,345	2,156,820	2,929,240	3,462,240
By suction dredge	9,891,090	6,681,490	12,441,430	13,894,310	10,488,530
Total	12,612,249	9,528,170	15,373,800	17,478,200	14,735,950
Authority, Tees Conservancy Commissioners					
By multi-bucket dredge	1,231,234	1,160,516	1,408,179	1,323,594	1,380,168
By grab bucket dredge	49,520	52,043	21,382	29,048	21,030
By suction dredge	—	252,051	220,863	614,641	555,219
Total	1,280,754	1,464,610	1,650,424	1,967,283	1,956,417
Authority, Port of London Authority					
By multi-bucket dredge	2,928,867	3,036,147	3,217,671	2,921,986	3,127,279
By grab bucket dredge	148,148	228,988	294,176	278,050	300,950
Total	3,077,015	3,265,135	3,511,847	3,200,036	3,428,229
Authority, Clyde Navigation Trust					
By multi-bucket dredge	1,561,875	1,178,025	1,156,050	966,375	1,075,275
By grab bucket dredge	172,970	136,308	148,237	146,325	177,525
Total	1,734,845	1,314,333	1,304,287	1,112,700	1,252,800
Authority, Port of Preston Authority (Ribble Navigation)					
By suction dredge	2,626,322	2,919,951	2,493,649	1,920,154	2,127,678
Total	2,626,322	2,919,951	2,493,649	1,920,154	2,127,678
	M.D. & H.B.	*T.C.C.*	*P.L.A.*	*C.N.T.*	*P.P.A.*
Average annual quanitity of spoil removed during period 1950/1954 in tons	13,945,674	1,663,898	3,296,452	1,343,793	2,417,551
Distance spoil is carried to deposit area in miles:					
Maximum	20	16	70	28	16
Minimum	4	1	45	10	4

means of transporting dredged spoil which does not come within the orbit of this address. The hydraulic transport of spoil by pumping through floating and shore pipelines is, where practicable, substantially the cheapest means of spoil transport. For a variety of reasons this method is little favoured in this country but is extremely popular overseas, particularly in the United States. It is of great use in capital dredging schemes but, for port maintenance dredging, spoil disposal by hopper barge or hopper dredge retains an almost undisputed supremacy.

In the dredging world a hopper is a receptacle or container into which dredged material is deposited. A hopper barge is a vessel fitted with a hopper into which dredged spoil is delivered by a dredge for carriage to deposit area. The hopper is generally fitted with bottom-opening doors or valves through which the spoil is dumped, but in certain circumstances closed bottom dry hoppers are also used. Hopper barges also serve other purposes, e.g. the carriage of ash from pulverised coal power stations, of steelworks slag and of the residue from sewage works. In the last type of vessel closed tanks are fitted instead of an open hopper.

A hopper dredge is equipped with a hopper into which the dredging plant discharges the spoil raised from the bottom through a distribution system. Such dredges may be of the multi-bucket, grab bucket or suction types. The multi-bucket hopper type is out of vogue though it had a long period of popularity and still has a limited use where small amounts of dredging are required at widely dispersed places. The grab bucket and suction types continue to grow in popularity, the former in this country and the latter overseas. In the United States the term "hopper dredge" is not qualified by "suction" because operators do not think in terms of bucket hopper or grab hopper dredges. Briefly then the hopper is an open compartment or hold designed to carry dredged material.

MATERIALS HANDLED

Sub-aqueous soils loaded by dredging into hoppers could be classed under the general headings that are given in Table II which, however, are not exhaustive. Soil densities vary substantially, hence the stowage ratings quoted are indicative only.

Each of these materials has some inherent feature which demands attention in design. It is obvious that a hopper designed to carry a cargo stowing at 18 cub. ft. per ton could carry appreciably more volume when loaded at 27 cub. ft. per ton provided the capacity was available. Conversely it is a very easy matter to overload a hopper designed specifically to carry any of the lighter spoils. Herein lies a danger against which the naval architect must protect himself. The hopper deadweight should be based on the class of material which the hopper is intended to carry and the freeboard and load drafts be arranged accordingly. For all general purposes an empirical stowage of 20 cub. ft. per ton is regarded as safe, but where a hopper is designed for, say 25 cub. ft. per ton material, physical safeguards against overloading should be incorporated.

Again the ease with which cargoes are released from hoppers through the bottom openings varies with the nature of the material. Silt drops out easily. Dumping a load of sticky mud usually presents no trouble except that the residual material clings to door chains, at points

TABLE II.—*Stowage Rates*

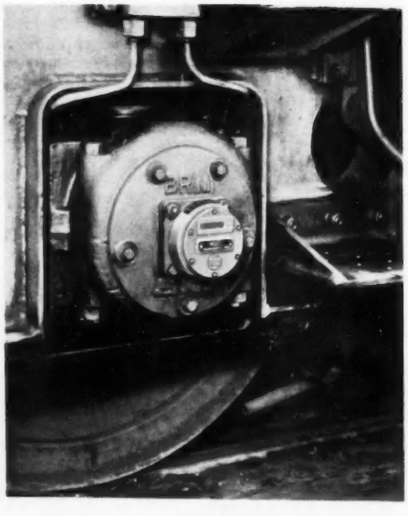
Material	Rates of Stowage in Hopper
Silt	25 to 29 cub. ft. per ton
Mud	21 to 23 " "
Sand and clay	18 to 20 " "
Sand and gravel	17 to 20 " "
Fine sand	17 to 19 " "

where the hopper plating or girders intersect near the bottom and at any structural members which break the smoothness of the downward flow. Medium and coarse sands release in general with the opening of the doors but very fine sands, or cargoes like fly ash from pulverised coal firing, may pack solidly in the hopper and tend to arch over the doors when these are opened. A sticky clay—and most clays are more or less—can be a perfect nuisance to dump. Rock cargoes have a high permeability and the design of the hopper should avoid jamming of the rock on dumping. Many rock cargoes are deposited on the training walls of navigable channels after the vessel is positioned over a certain spot. This work is frequently done in shallow waters and requires that, when open, the doors should not protrude below the bottom of the ship.

MILEAGE RECORDER FOR RAILWAY SERVICE

The accompanying illustration shows a mileage recorder which has been designed by the British Thomson-Houston Company, Limited, Rugby, for mounting on the axle-box of a locomotive or other rolling stock. Such an instrument enables mileage records to be obtained, data which are important in securing efficient operation.

The new recorder is available in two forms, one being a complete counter unit with drive and resilient mounting, so that it is suitable for attachment to the axle box cover. In construction it is identical and interchangeable with the firm's Type B tachogenerator for axle-shaft drive. The other form is a counter unit, which is suitable for use with the Type C tachogenerator and is driven from the generator shaft.



A mileage recorder, of B.T.H. design, mounted in the axle-box cover of a locomotive.

Essentially the recorder comprises a six-figure counter assembly, the first wheel of which registers tenths of a mile and is actuated through reduction gearing from the axle of the track wheel. The driving member can be varied to suit particular requirements, suitable for wheel track diameters from 26·5 to 55 in.

The mileage recorded is a function of the actual track wheel diameter and the gearing of the recorder. This gearing is chosen to match, as closely as possible, the mean diameter of the track wheel, taking into account the maximum track wear. Small errors, due to variations in wheel diameter, therefore tend to cancel out over the life of the tyre. A correction factor, which relates to the nominal wheel diameter as determined by the gearing, may be applied if more precise mileage figures are required over a brief period. For normal record purposes, however, the mileage figures shown are of sufficient accuracy as the maximum error at any time will not exceed about 4 per cent.

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PLASTICS INSULATION

An interesting insulation problem arose at the Reddish Electric Traction Depot, which forms part of the Manchester-Sheffield electrification scheme, when it was decided to attach the specially designed Ediswan lighting units to the structures carrying the 1,500 volt direct-current overhead power lines. A steel bracket arm with a shrunk-on covering, 1½ to 2 mm. thick, of polyvinyl chloride was therefore developed to provide insulation and resistance to compression at the clamping point. The box holding the incoming service and the self-sustaining winch, which has been provided so that the lanterns can be serviced at ground level, was also attached to the mast by ½ in. mild-steel bars which were insulated by polyvinyl-chloride tube.

MECHANICAL HANDLING

3—CONVEYORS

Continued from page 350

In the last two issues of ENGINEERING, some of the cranes, loading shovels, trucks and tractors on view at the Mechanical Handling Exhibition at Earl's Court—which closes on May 19—have been described. This week we deal with some of the conveyors on view.

PASSENGER MOVEMENT

An American project for carrying passengers by belt conveyor, which may have far-reaching effects on local passenger transportation, is displayed in model form by the Goodyear Tyre and Rubber Company in conjunction with Richard Sutcliffe, Limited, who are licensed to manufacture the equipment in the United Kingdom. The system has been developed by the American Goodyear Tyre and Rubber Company in conjunction with the Stephens-Adamson Manufacturing Company, Aurora, Illinois. The system is already in operation at the works of the latter company, and design studies have been worked out for large-scale installations such as the replacement of the present shuttle service between New York Grand Central Station and Times Square, capable of handling 36,000 passengers instead of the present 23,000.

In this new project, passengers arriving at the station all go to one platform where a 60 ft. long moving belt (called the " Speedwalk ") is running at a constant speed of 1½ m.p.h. Alongside this, where the train tracks would normally be, is another conveyor belt moving at the same speed on which 19 separate passenger cars are arriving every minute. The capacity of these cars is matched to the traffic density to be handled, and in the New York project would probably hold 10 to 15 passengers.

Once on the Speedwalk, all the passenger has to do is to step into the carriage, the doors of which have already opened automatically. Once clear of the Speedwalk the doors shut automatically, and the carriage rolls over a bank of tyred accelerator wheels which quickly step up the speed of the conveyor from 1½ to 15 m.p.h. Spacing is increased as the cars are placed on this main line conveyor.

When the terminus is reached the carriages are slowed down over a bank of decelerator wheels, and are delivered bumper-to-bumper (19 cars per minute) to the off-loading Speedwalk which also moves at 1½ m.p.h.

Having arrived at their first destination and emptied, the cars then describe an arc on banks of powered wheels equipped with pneumatic tyres to pick up their passengers on the other side for the return trip, when the whole process is repeated. The journey from Grand Central Station to Times Square would take 2 minutes each way. The Speedwalk passenger conveyor is arousing considerable interest in the United States, and six installations already are working at railway stations, industrial works and baseball parks.

TAPE-CONTROLLED CONVEYOR AND TRANSFER SYSTEM

An important development demonstrated by Fisher and Ludlow, Limited, Material Handling Division, Bordesley Works, Birmingham, 12, is the Flowmaster electronically controlled conveyor system designed by them in collaboration with the E.M.I. Engineering Development organisation. In this system, a teleprinter translates the operator's requirements on to punched tape, which is then fed into an electronic reader converting the operator's signals to electrical impulses. An E.M.I. control unit interprets the instruction from the reader, operates the conveyor control mechanism, and checks that it has been carried out before accepting the next one.

The tape link in the chain of automatic processes is the transfer of a component from the conveyor to and from a representation of an automatic machine, the complete cycle being automatically operated and controlled by the conveyors.

To illustrate the new system, the demonstration conveyors at Earl's Court incorporate two storage conveyor lines, called " Red Line " and " Yellow Line ": the required assembly operation sequence may call for " red," " yellow," " red," " red," " yellow," " yellow," " yellow," " red." The punched tape covering this requirement is fed into the reading machine and the emerging electrical impulses are translated by the E.M.I. controller into movements of the index mechanism of the storage conveyors, so allowing the appropriate components to move from the storage conveyors to the main conveyor system. The main conveyor transports the components to their destinations, these being automatically determined through pre-selectors built into the Flowmaster system.

Safeguards are incorporated so that should a component called for by the tape not be available in the storage conveyor, the tape will remain stationary holding the programme until the required component becomes available. Thus, only if each sequence and operation has been correctly performed can the next step or sequence be initiated.

The speed at which the tape is fed into the reader and, therefore, the speed at which the sequences or operations are performed, is controlled by the chain speed of the main Flowmaster conveyor, so that when it stops, the reader stops, and the E.M.I. controller does not release any more components to the main conveyor.

The number of components which can be released to the main conveyor in a given period of time is proportionate to the number of pawls on the main conveyor, which pass a control point connected to the E.M.I. controller.

INDEXING TRAY CONVEYOR

A pneumatically-operated tray conveyor (Fig. 12) with an indexing movement suitable for automatic operations is displayed by the Abisch Conveyor and Furnace Company, Limited, 194–196, Finchley-road, London, N.W.3.

The conveyor trays, which operate on a closed circuit, are pushed intermittently along an upper track to a discharge platform which lowers the tray to the return conveyor. The latter transfers the tray to a feed platform which lifts it back to the top track, completing the circuit.

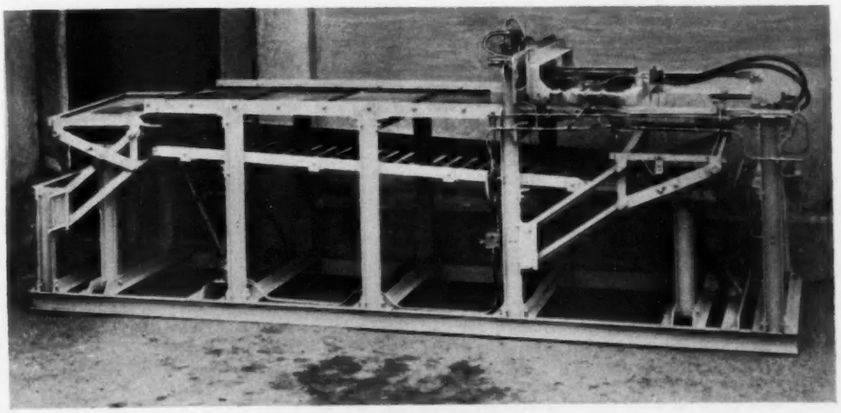

Fig. 12 Pneumatic tray conveyor with indexing movement: Abisch Conveyor and Furnace Co. Ltd.

SLIDING ASHES ON AIR

Among the exhibits on the stand of Babcock and Wilcox, Limited, Babcock House, Farringdon-street, London, E.C.4, is an animated display showing the operation of a low-pressure pneumatic fly-ash handling system of the type installed at Brimsdown power station.

This system is a comparatively new development in the technique of handling fly-ash and can be arranged to convey 20 to 100 tons per hour up to distances of ½ mile. It is arranged to handle fly-ash dry, a valuable feature if commercial use of the ash is contemplated. The gravity conveyor system consists of an inclined trunking, which has a " floor " section made up of a fabric porous to air and resistant to high temperatures. The air pressure applied beneath this fabric cushions the dust on it so that the ash will flow freely down an incline of 5 deg. Where long distances are involved, this system is used to collect the ash from several different boilers and convey it to a transfer point where it is collected from a buffer hopper by a Fuller-Kinyon pump, and transferred to a storage silo by compressed air.

Fig. 13 Heavy-duty steel trough conveyor for curved track: Wharton Engineers (Elstree), Ltd.

STEEL CURVED TRACK CONVEYOR

Illustrated in Fig. 13 is the new steel-link conveyor exhibited by Wharton Engineers (Elstree) Limited, Elstree, Hertfordshire, for heavy-duty operation on curved track, with a capacity of over 400 tons per hour and capable of carrying hot materials at temperatures up to 900 deg. F. There are no open spaces between

the trough plates when passing curves. The conveyor operates on mine-type rails and has a single driving chain. For long lengths of track intermediate drive units are available so that the main driving motors can be kept to minimum power.

SCREW CONVEYORS FOR GRANULAR MATERIALS

The Handyloader screw conveyor exhibited by Mitchell, Colman and Company, Limited, Hollybank-street, Radcliffe, Manchester, has been designed for use on farms, for handling and loading grain and other free-flowing materials. It is readily portable, as it weighs less than 35 lb. For most duties, a ½ h.p. motor is required to drive the screw. Mounted on a bracket at the delivery end, the motor can be arranged either for belt or direct drive.

The Handyloader, which is fitted with a collapsible feed hopper, is available in three lengths—9 ft., 12 ft. and 15 ft. The basic unit is 9 ft. long, and 3 ft. or 6 ft. extensions can be added. Typical throughputs, with the Handyloader set at various angles to the horizontal, are as follows: vertical, 1 ton per hour; 60 deg., 3 tons per hour; 45 deg., 4 tons per hour; 30 deg., 5 tons per hour.

The Screw-Lift conveyor shown by W. S. Barron and Son, Limited, Bristol-road, Gloucester, is manufactured under lincence from the Screw Conveyor Corporation of America. Designed for elevating most granular materials, it is suited to the needs of certain chemical plants, food processing industries and provender millers. It is also capable of elevating wet brewers' grains, which are difficult to handle on other types of conveyor.

The Screw-Lift is a vertical worm elevator manufactured in four sizes, from 4 in. diameter to 12 in. diameter, capable of handling throughputs from 75 cub. ft. to 2,500 cub. ft. per hour. The drive gearbox can be either mounted at the head, with a gravity feed opening; or the elevator can be provided with a bottom drive, and in this case it can be used in conjunction with a horizontal screw feed conveyor driven from the vertical shaft. This latter version is suitable for all types of free-flowing bulk materials, as well as soft stocks such as flour and starch.

A tapered endless screw receives the material from the feeder and starts the vertical movement without compression, ensuring that there is no damage to the stock. The intermediate bearings are designed to offer the minimum of obstruction.

ISOTOPE CARRIER

Developments in air-tube carrier systems shown by the Lamson Engineering Company, Limited, 6, 7 and 8 Hythe-road, Willesden Junction, London, include an automatic isotope loading device which permits isotopes to be loaded on the carrier system and dispatched untouched by hand. It consists of a terminal in which a specially-designed carrier is held open by an electromagnet incorporating a stop which retains the carrier at the terminal until the isotope is dropped inside.

When the isotope touches the bottom of the carrier, the spring-loaded lid of the carrier is released and the stop is withdrawn from beneath the carrier so that the latter, with the isotope inside it, moves away through the system to the point of discharge. With this arrangement it is possible to load isotopes at a central bank for distribution to various distant points.

CONVEYOR BELTING AND COMPONENTS

Heat resistant and fire-resistant conveyor belts are among the exhibits of the Silvertown Rubber Company, Limited, Herga House, Vincent-square, London, S.W.1. For use underground, they are showing a flexible belt with ample lateral firmness for heavy loads, resistant to abrasion, gouging and cutting; a light-weight belt specially designed for service at the coal face, capable of gripping small diameter drums; and an exceptionally robust belt for heavy duty.

The belt seen in Fig. 14 , exhibited by the British Tyre and Rubber Company, Limited, Herga House, Vincent-square, London, S.W.1, is designed for carrying very abrasive materials at temperatures up to 230 deg. F.; it is recommended for conveying sinter, hot sand, castings, cement clinker, coke, bricks, glasscullet, etc. Other heat-resisting B.T.R. belts on view include one with a glass-fibre carcass that can be used at temperatures up to 350 deg. F., or even higher temperatures for short periods.

A new type of polyvinyl chloride coated belting is exhibited by Gandy, Limited, Wheatland Works, Wallesey, Cheshire, which can be rapidly manufactured, and very easily made endless on site with the minimum of apparatus.

New types of base fabrics, such as high tenacity rayon, are used in the fire-resistant conveyor beltings shown by Rubber Improvement Limited, Rilex Works, Wellingborough, Northamptonshire. This company have also done much research work on the elimination of the build-up of static electricity on belting, and have developed an anti-static belting particularly suitable for handling high explosive materials.

DRIVING HEAD FOR BELT CONVEYOR

A new design of belt-conveyor driving head, known as the Panther 30, is shown by Richard Sutcliffe, Limited, Horbury, Wakefield. A single-drum driving head, the Panther 30 is designed for industrial conveyors and transmits 30 h.p. at a range of belt speeds from 160 ft. per minute to 280 ft. per minute (Fig. 15).

It is suitable for belts from 20 in. to 54 in. wide and is fitted with a 27 in. diameter driving drum and a 12 in. diameter snub drum. The motor is spigot-mounted to the gearcase, with the first-reduction pinion keyed to the motor output shaft, thus dispensing with a separate coupling. The speed reduction is through a double train of high-grade hardened steel gears, mounted on ball bearings in a cast-iron gearbox. The final-reduction wheel is keyed directly to the driving-drum shaft, thus ensuring a highly efficient drive. The top half of the gearcase can be removed for inspection without disturbing the alignment of the gears.

The machine is designed so that the drive unit can be assembled either hand or changed over on site to suit varying conditions.

OVERHEAD CONVEYORS

Other interesting conveyors demonstrated at the exhibition include the Stanorun overhead chain conveyor for production shops, shown by Geo. W. King, Limited, Stevenage and Hitchin, Hertfordshire, which incorporates selective conveying, automatic storage and transfer units; an ultra-lightweight pre-selective overhead chain conveyor (patent application No. 27276/54) exhibited by Sovex Limited, Erith, Kent, developed originally for routing garments in the dyeing and cleaning industry, but equally suitable for handling light parts on the shop floor or in the warehouse; and the Charlton carriage for ski-lifts, shown by the British Ropeway Engineering Company, Limited, Plantation House, Mincing Lane, London, E.C.3, who have recently installed a ski-lift of this type for the Scottish Ski Club.

Fig. 14 Conveyor belt for hot and abrasive material: British Tyre and Rubber Co. Ltd.

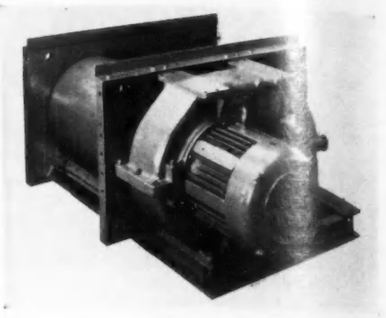

Fig. 15 30 h.p. single-drum conveyor driving head: Richard Sutcliffe, Ltd.

To be continued

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SPARK MACHINING DEMONSTRATED

Mobile Unit Visits Factories

In order to demonstrate to interested manufacturers the use and possibilities of the Sparcatron equipment for machining by spark erosion, which is manufactured by Impregnated Diamond Products, Limited, Tuffley-crescent, Gloucester, a mobile demonstration van has been introduced by the marketing agents, Burton, Griffiths and Company, Limited, Mackadown-lane, Kitts Green, Birmingham 33.

The unit comprises an Austin van with a specially designed body in which is housed the standard Sparcatron unit and a self-contained petrol-driven generating set for providing electrical power when a mains supply is not readily available.

The Sparcatron spark-machining process was described in the November 26, 1954, issue of ENGINEERING (page 698, vol. 178). Briefly, it may be recalled that it provides a simple means for cutting hard materials such as cemented carbide, titanium and its alloys, etc., which cannot readily be machined by conventional cutting and grinding tools. Moreover, high-strength steels can be machined by the Sparcatron process in the fully heat-treated condition without any local heating effects and loss of mechanical properties. The cutting process produces a smooth non-directional surface finish (35 micro-inch) with lubricant-retaining properties. It is also possible to carry out intricate machining operations which by any other means would require a succession of costly processes and in some cases might even be impossible.

Spark machining is particularly suitable for producing form tools, extrusion dies, and tool-room renovation. It has been used for machining an 8-vane impeller, the operation taking 55 hours instead of the 5 weeks by conventional methods. The Bristol Aeroplane Company are using the process for renovating turbine-blade dies, and the aircraft industry are interested in its possibilities for accurately machining the large-scale models used in wind-tunnel tests. The growing interest in the process, which is economically within the range of the small manufacturer, has led to the introduction of five-day courses in spark machining at the Production Engineering Research Association.

PRODUCING "TOOTHPASTE" TUBES

AUTOMATION INCREASES OUTPUT

The collapsible tube has, of recent years, become a standard feature of daily life and the range of products that are now packed in these convenient containers is rapidly increasing. The list now includes such items as condensed milk, salad dressing and caviare as well as more familiar items such as paints, adhesives and toilet preparations. To meet the rapidly increasing demand, Venesta Limited, Vintry House, Queen Street-place, London, E.C.4, have, during the last two years, installed flow-line units at their Silvertown works to replace the older system of batching. On these flow-lines, where the approach to automation is almost complete, 55 tubes can be produced per minute, as compared with 38 on the batching plant. Moreover, the number of operators required is reduced from eight to four. Although some standard machines and equipment are used in the flow-lines, much of the plant, and particularly the transfer mechanisms, was designed by the company.

The materials used in the manufacture of the tubes are tin, lead, lead alloy, tin-coated lead and aluminium. The last named now accounts for 57 per cent. of all British tube manufacture. Materials are chosen to suit the intended contents of the tube, but for some substances it may be necessary to coat the inside of the tube with a lacquer to prevent any possible reaction which might cause the contents to deteriorate during long storage periods. The outside of the tube is normally enamelled and then has the description printed on it. Whether made on the batch machines or on the flow-lines, the tubes are initially formed from a "dump" ("slug", if of aluminium) by impact extrusion, and the sequence of operations is the same. Work flow in the factory is from the outside towards the centre where the packed tubes are stacked on pallets and removed by fork truck. Lightweight pallets of plywood squares separated by straw-board cylinders have been designed by the firm for this use in consultation with the Institute of Materials Handling.

IMPACT EXTRUSION

To make the dumps, ingots of the metal or alloy are melted and cast into slabs. The slabs are then rolled to the required thickness and the dumps punched out of the resulting strip. To produce tin-covered tubes, tin foil is laid on both sides of the slab during rolling, the pressure being sufficient to ensure adhesion. After punching, the dumps, which are circular discs of the same outside diameter as the finished tube, are rumbled with a powder which supplies the necessary lubrication for the extrusion process. To facilitate extrusion, the aluminium slugs have a central hole punched in them. They are then transported to the feeding hoppers of the extrusion presses. After inspection, the dumps are fed mechanically into the presses which in the case of the flow-line arrangements are horizontal machines. Fig. 1 is taken looking down into the mechanism of one of them; a tube has just been extruded and is shown still in place on the male portion of the die. On the left is the stripping mechanism and in the foreground is a moulded tube being carried away on a conveyor belt. The impact force of these machines is approximately 60 tons. At this stage, aluminium tubes require an additional annealing operation, for this material has to be extruded "hard" to obtain good results.

The next operation is forming the thread for the cap on the nozzle and cutting the tube body to the correct length. These operations are carried out simultaneously on a series of mandrels mounted on a wheel rotating in the vertical plane. The tubes arriving on the conveyor belt from the press are pushed mechanically on to the mandrels, which have a splined end designed to fit inside the nozzle portion of the tube in order to grip the tube while the cutting and trimming operations take place. Rolling is used to form the thread. When these operations are completed, mechanical fingers strip the tube from the mandrel in such a way that the finished portion falls down one chute, while the waste end falls down another. The tubes are then conveyed to the enamelling machine in which they are once again mounted on mandrels on a vertical wheel which during rotation brings them into contact with the paint roller. This operation is shown in Fig. 2. They are then transferred by hand to the peg conveyor which carries them through the first drying oven.

The enamel is only partly dried in the first

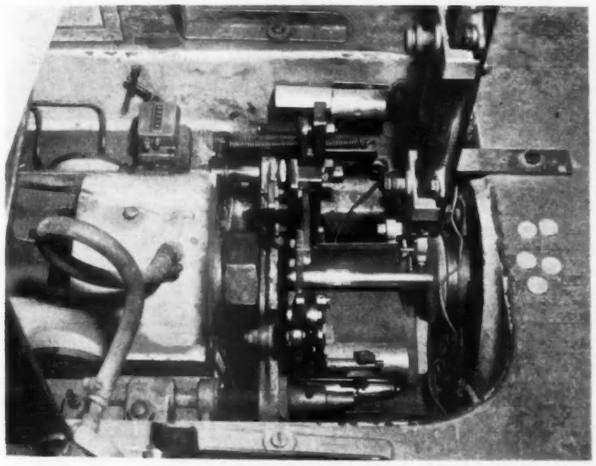


Fig. 1 The tubes are formed by impact extrusion from a "dump" of material. Horizontal presses are used in the flow-lines. The formed tubes are pneumatically stripped from the die and fall on to a belt conveyor.

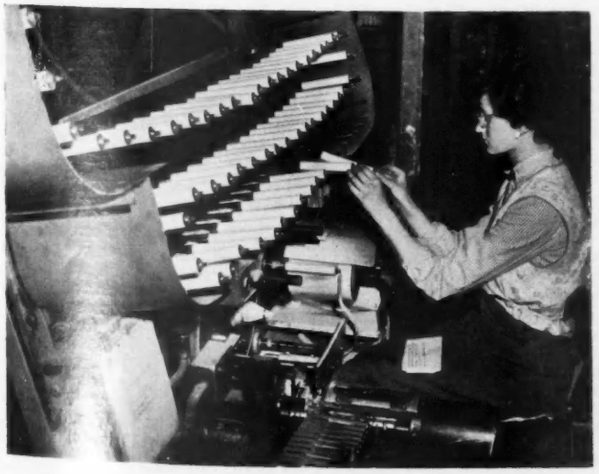


Fig. 2 After having the cap thread rolled and the ends trimmed, the tubes are mechanically transferred to mandrels mounted on a rotating wheel which brings them in contact with the enamelling roller.

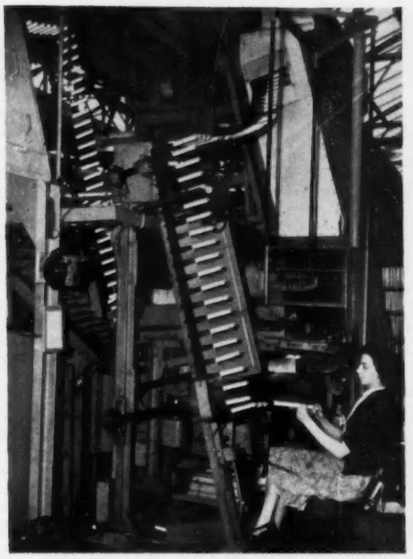


Fig. 3 The enamel is partly dried in an oven and the tubes mechanically transferred from the peg conveyor to a second mandrel wheel which brings them in contact with the print roller. Drying is completed in a second oven.

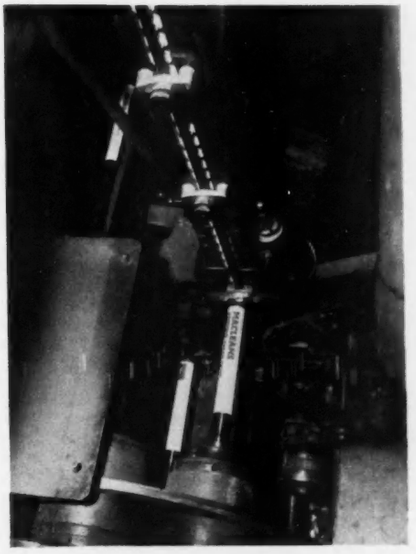


Fig. 4 The last operation is fitting the cap, which is again performed mechanically. The completed tube is passed by conveyor to the inspection bench and is afterwards packed.

oven, and the tubes are transferred mechanically to another vertical wheel and the wording and design are printed on them. The tacky enamel gives a good adhesive surface for the printing which may be in as many as four colours. In the left background of Fig. 3 is the conveyor bringing the tubes from the first oven and in the centre they are being conveyed to the second after printing. After emerging from the second oven, the completely dry tubes are fed to the capping machine, part of which is shown in Fig. 4. In this the principle of rotating mandrels is again used. The tubes are pushed on to the mandrels, then registered and next a cap from the chute is screwed on to them. They are then stripped from the mandrel and taken by a conveyor to the inspection station, after which they are packed ready for dispatch. The mechanical fitting of the caps has the advantage that all are screwed on with the same degree of tightness.

It is a comparatively simple matter to change from one size of tube to another, for all that is needed is to change the die and the various mandrels, and to adjust the position of the enamel and print rollers, all of which can be done with little difficulty. This enables a wide range of tube sizes to be handled and those already made range from $\frac{3}{8}$ in. in diameter by $2\frac{1}{4}$ in. long to $2\frac{1}{4}$ in. in diameter by 10 in. long and are designed to hold a great variety of products. Attached to the works is a laboratory where the reactions between the materials of the tube and its future contents can be studied so that the former can be chosen to prevent any deterioration occurring.

* * *

ANCIENT NAVIGATING INSTRUMENTS

Important Collection at Greenwich Maritime Museum

By the collaboration of their owners all the four mariner's astrolabes known to exist in this country are now being exhibited at the National Maritime Museum, Greenwich, and it is hoped that it will be possible to keep then on view throughout the summer. It may be noted that only nine of these instruments are known to exist in the whole world, so that nearly half the total number can be seen and compared at Greenwich. The mariner's astrolabe is an adaptation of the astronomical astrolabe of which a comparatively larger number (about 750) are known to exist; incidentally, the National Maritime Museum has a fine collection of about 50 of them. Most astronomer's astrolabes had on the back a graduated scale with a sighting alidade which could be used for observational purposes, the remainder of the instrument being used for calculations. The observational part was found so useful for navigation that a special instrument was made for the use of mariners, the essential parts of which were made very heavy so that it was not affected by wind but hung steadily in the vertical plane. With it, the angular elevation of the sun or of the Pole Star could be determined, as with a sextant, and the latitude of the observer calculated from the readings.

Of the four instruments being shown at Greenwich, the oldest is dated 1555, but has only recently come to light; it belongs to the Albert Institute, Dundee. The second astrolabe was found in 1845, under a rock in the island of Valentia, Co. Kerry, near the spot where three vessels of the Spanish Armada were wrecked. This instrument was formerly in the Science Museum, but is now owned by the National Maritime Museum. The third astrolabe was brought up by a sand-pump dredger from the bottom of Vera Cruz harbour; it is the property of the Museum of the History of Science, Oxford. The fourth is the work of the English instrument maker Elias Allen who made it in 1616; it is now in the possession of St. Andrews University.

NOTICES OF MEETINGS

British Institution of Radio Engineers

LONDON
"The Measurement of the Velocity of 'Light' by Electronic Methods," by K. Froome. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 23, 6.30 p.m.*

Building Centre

LONDON
Films Illustrating Building Plant and Machinery. Wed., May 30, 12.45 p.m.

Chemical Society

LONDON
Centenary Lecture on "The Present Status of the Transuranium Elements," by Professor G. T. Seaborg. Thurs., June 7, 7.30 p.m.

LIVERPOOL
Centenary Lecture on "The Present Status of the Transuranium Elements," by Professor G. T. Seaborg. Chemistry Lecture Theatre, The University, Liverpool. Tues., June 5, 5.30 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Legal Aspects of Boiler Operation and Maintenance," by G. A. Anderson. Birmingham Branch. Imperial Hotel, Birmingham. Fri., May 25, 7.30 p.m.

SHEFFIELD
Various short papers by branch members. Sheffield Branch. Grand Hotel, Sheffield. Thurs., May 31, 7.30 p.m.

Institute of Petroleum

LONDON
"Future of the Petroleum Industry in the United Kingdom," by C. P. Dalton. London Branch. Wed., May 23, 6 p.m.

Institution of Civil Engineers

LONDON
"Kwinana Jetty," by Peter Murray and D. N. Collett. Works Construction Division. Tues., May 29, 5.30 p.m.*
Annual General Meeting (Corporate Members only). Tues., June 5, 5.30 p.m.*

Institution of Electrical Engineers

EDINBURGH
Annual General Meeting. Scottish Centre. Carlton Hotel, North Bridge, Edinburgh. Tues., May 22, 7 p.m.

Institution of Mechanical Engineers

BIRMINGHAM
Annual General Meeting and Chairman's Address. Midland Graduates' Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., May 28, 6 p.m.

Institution of Naval Architects

LONDON
"The Planing Performance, Pressures and Stresses in a High-Speed Launch," by Commander P. Du Cane, R.N. (Rtd.). Thurs., June 7, 4.45 p.m.*

Institution of Production Engineers

PETERBOROUGH
One-day conference on "Aspects of Automation." North Midlands Regional Meeting. At works of F. Perkins, Ltd., Peterborough. Sat., June 2, 10 a.m.

Institution of Structural Engineers

LONDON
Annual General Meeting. Thurs., May 24, 6 p.m.

Royal Institution

LONDON
"The Structure of Metals as Seen under the Microscope," by Professor Cyril S. Smith (University of Chicago). Fri., May 25, 9 p.m.

Royal Society

LONDON
Croonian Lecture on "Some Experiments About Thinking," by Sir Frederick Bartlett. Thurs., May 31, 4.30 p.m.*

Royal Society of Arts

LONDON
"The Influence of National Character on Design," by Paul Reilly. Wed., June 6, 2.30 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. "Process Analytical Instrumentation," by A. G. Stanley and J. F. Brown. Manson House, 26 Portland-place, W.1. Tues., May 29, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceeding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

SCIENTIFIC INSTRUMENTS

ANNUAL DISPLAY BY THE PHYSICAL SOCIETY

This year's Exhibition staged by the Physical Society at the Royal Horticultural Halls, London, was the fortieth in the series. Both old and new halls were used to house the 131 stands that made up this year's show. The official opening was on May 14, by Sir John Cockcroft, K.C.B., K.B.E., F.R.S., and it remained open for four days closing on the 17th.

As in past years discourses and demonstration lectures were given in the evenings, one by Mr. H. G. Jenkins on "Recent Developments in Light Sources," the second by Professor H. Lipson on the "Production of Images of Chemical Molecules," and the third by Mr. G. G. Gouriet on "Colour Television: Considerations which have Led to Recent Trends."

The instruments and apparatus exhibited once again represented some of the latest developments in physics and electronics. The fields covered were very wide including such items as microscopes, spectrophotometers and radiation meters, as well as oscilloscopes, oscillators and the like. It is quite impossible to give a complete report of the hundreds of items shown but outlines of some of them are given in the short descriptions which follow.

PHOTOGRAPHIC RECORD DEVELOPER

Among several exhibits shown on the stand of Southern Instruments, Limited, Frimley-road, Camberley, Surrey, was an auto-developer designed for processing oscillograph records under daylight conditions without a dark room. It will develop, fix and dry photographic paper up to 150 mm. wide and 250 ft. long for each charge of the solutions. The box-shaped apparatus stands on the table and the record is transferred from the camera either in a black cloth bag or in a cassette, and the operator manipulates the roll in the box through black cloth sleeves. The paper passes through guide rolls, which lead it first into the developing tank and then through the fixing tank. On emergence from the latter it passes between electrically heated plates which dry it, and then to the drive rolls which pull it through the whole process. The record emerges from the end of the box at a uniform speed of 3·1 cm. per second, ready for examination, or it can be respooled on a rewind machine. The developing and fixing tanks are provided with immersion heaters that maintain the temperature constant after an initial heating period of about five minutes. The heaters operate from 230 volts alternating current. The processing compartment has a hinged cover and hinged frame to give easy access to the tanks and the drier. The power consumed is approximately 2·8 kW and the box measures 35 in. by 16 in. by 13 in. with a total weight of 92 lb.

MECHANICAL DIGITIZER

Both divisions of Hilger and Watts, Limited, 98, St. Pancras-way, London, N.W.1, were

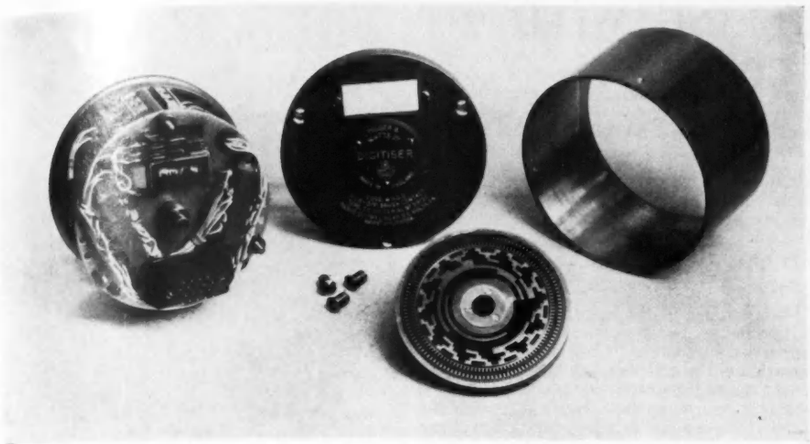


Fig. 1 Mechanical digitiser for dividing one revolution into 1,000 parts: Hilger and Watts, Ltd.

exhibiting apparatus on the same stand. Apparatus included spectrographs, X-ray units, and a complete 3 metre polychrometer. There were also several examples of digitisers, devices which divide a circle into many parts, for use with teleprinters, typewriters or computers. The one shown in the illustration, Fig. 1, is a 1,000 division model which operates with a brush pick-off. The unit is arranged to divide a single rotation of the shaft into 1,000 parts without additional gearing. It is coded in a binary system and the coded disc is metallic with insulated sectors; contact with the disc is made by stainless steel balls located in bushed holes in carrier plates, ensuring that replacement of the balls does not require any skill, since the alignment is fixed. Brush tolerances are increased on the inner rows, and ambiguities avoided by having a double-sided disc with automatic adjusting. Means for zeroing through 360 deg. by rotation of the brush-carriers is also provided. These digitisers are intended normally for static read-off into relay circuits. The torque required to drive them is approximately 12 inch-ounces. A model with photo-electric pick-off is also made having a glass coded disc with clear and opaque markings giving 10,000 divisions per revolution. The scale is continuous and unambiguous, switching being performed in transistor circuits; the driving torque is less than one gramme-centimetre and the model is particularly useful for high-speed computers.

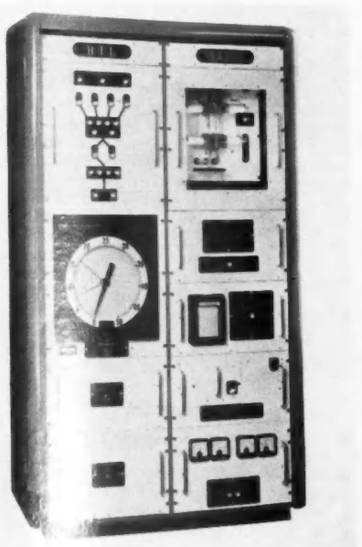


Fig. 2 A[illegible]atic apparatus for routine laboratory tes[illegible]aird and Tatlock (London), Ltd.

AUTOMATIC LABORATORY APPARATUS

Automation has now invaded the laboratory and Messrs. Baird and Tatlock (London), Limited, 14/17, St. Cross-street, Hatton-garden, London, E.C.1, were showing their Analmatic series of instruments. These included equipment for specific tests such as the Karl Fischer titrations and also built-up equipment for other routine testing. An example of the latter included a *p*H unit and an absorptiometer unit as shown in Fig. 2. The range at present developed is mainly intended for use in connection with large scale continuous chemical processes, since it is equipped to sample and analyse a specific liquor or gas automatically, and to provide a record of the results without human aid. Individual units are arranged to carry out specific laboratory tasks and are controlled by other units which govern the order and performance, and record the results. The use of such equipment relieves skilled men from the necessity of routine work, which is an important factor with the present shortage of skilled labour.

INSTRUMENT RECORDING CAMERA

On the stand of W. Vinten, Limited, North Circular-road, London, N.W.2, was a range of cameras intended for special purposes. One of these is designed expressly for the photographic recording of instrument test panels. The camera is completely self-contained and operated from a battery. Standard 35 mm. cinematograph film in 200 ft. lengths is used, each cassette containing enough film for 3,200 exposures. One complete length can be run through the camera in one minute, or in 53 minutes at the minimum speed of one frame per second, the speed range being attained by four alternative gearboxes. Single exposures can be made at random intervals by means of a manually-operated switch. For setting up the camera, a direct view of the actual image is used which avoids any parallax errors between the taking and finder lenses. To enable this to be done a lower power magnifying eyepiece is mounted on the door and can be swung out of position when not required. Exposure times are adjustable within wide limits and are varied by altering the angle of opening of the rotary shutter which rotates once for each exposure. A choice of 15 values is obtainable. The camera, with one drive unit in position ready for use, weighs 13¾ lb. and measures 11 in. long by 8 in. wide by 8 in. high.

TORQUE BALANCE METER

A torque balance meter which is designed to indicate a quantity proportional to the applied power was shown on the stand of Salford Electrical Instruments, Limited, Peel Works, Silk-street, Salford, 3, Lancashire; it is illustrated in Fig. 3. The unit consists of two electrical instrument movements directly coupled by a mechanical link. The originating movement is varied to suit the type of measurement required; for example if it is required to indicate power a watt meter is used, for other purposes it may be an ammeter or voltmeter. The balancing movement is a moving-coil direct-current instrument fitted with maximum and minimum contacts. The contacts are arranged to energise a 50 outlet both-way telephone uni-selector to which a switching circuit has been added, making 100 outlets available. These are wired to a bank of resistors and thereby form a tapped potentiometer. The potentiometer is energised from a rectifier supply and the output is fed to the coils of the direct current moving-coil relay together with any required number of slave indicators. When the originating movement is energised it deflects, and the contacts on one side of the relay are closed, thus energising one side of the uni-selector. The uni-selector steps round varying the output of the potentiometer to produce the required torque in the moving coil relay to balance the torque in the originating movement and break the relay contacts. The moving coil indicators connected in series with the relay coil will thus indicate a quantity proportional to the applied power.

Also being shown by Salford Electrical Instruments, Limited, was a clip-on layer thickness meter illustrated in Fig. 4. The instrument is a modified version of the link-test ammeter. The normal moving iron indicator is biased with a permanent magnet and the iron circuit poles are so modified that when varying thicknesses of non-ferrous material are placed in the gap of the links a change in indication occurs due to the introduction of an air gap into the magnetic system. The scale of the instrument can be directly calibrated in 1,000ths of an inch.

Other items included a range of linear function sub-miniature potentiometers, the smallest of which measures ⅛ in. in diameter by ½ in. long, not including terminal projections. Miniature 7 mm. selenium and copper oxide rectifiers were shown as well, for currents of 0·5, 1, 2·5 and 5 milli-amperes.

To be continued

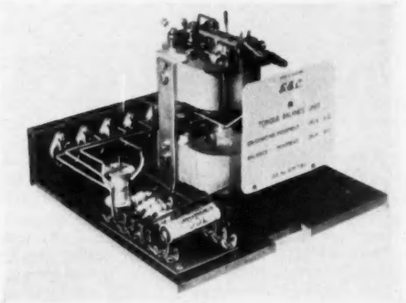


Fig. 3 Torque balance meter: Salford Electrical Instruments, Ltd.

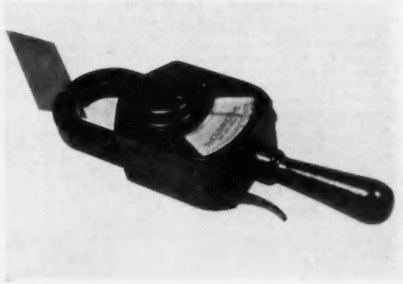


Fig. 4 Layer thickness meter: Salford Electrical Instruments, Ltd.

PRODUCTION MILLING WITH AUTOMATIC CONTROL

ECONOMIC OPERATION ON LARGE OR SMALL BATCHES

The " Centec 3 " production milling machine, made by the Central Tool and Equipment Company, Limited, Maylands-avenue, Hemel Hempstead, Hertfordshire, is basically a horizontal-type machine with a working surface to the table of 8 in. by 30 in. and a powered table traverse of 14 in. It embodies so many new and special features, however, that it can carry out a very large range of milling operations under automatic control, and is capable of many types of work not hitherto considered as suitable for a milling machine. For this reason the manufacturers prefer, if possible, to discuss the machine with prospective users at the stage when they are designing their products; the full potentialities of the machine can then be used to the best advantage.

The machine can operate two-dimensionally, and work automatically to a programme consisting of any number of horizontal and vertical movements. Cycle-setting is extremely simple, and floor-to-floor times are reduced greatly by the very high speed idle movements of the table and cutter head. No skilled labour is needed for operating the machine, which can, if required, be set up to work with hopper feed.

INFINITELY-VARIABLE SPEEDS AND FEEDS

The main drive of the machine is by direct-current motor, fed and controlled electronically from a three-phase alternating-current supply. The spindle speed is controlled by a single dial operating a rheostat, and there is a two-speed gearbox which splits the speed range. Either one of two speed ranges is supplied as standard, the speeds being 50 to 275 and 275 to 1,400, or 200 to 550 and 600 to 2,800 r.p.m. A dynamic braking circuit stops the spindle when the stop button is pressed or when the automatic spindle stop is used. Automatic stopping and re-starting of the spindle are possible at any point in the table cycle. The electronic control gear, which incorporates two thyratrons, is self-contained and built into a drawer which pulls out from the back of the machine pedestal.

The table feed is hydraulic, with infinitely-variable speed control, the range being from $\frac{3}{4}$ in. to 36 in. per minute. A dial is provided for speed setting. A special circuit is employed for an automatic operating cycle, with a fast approach of the work to the cutter, then a slow feed, and finally fast return. This cycle can be repeated on the same stroke when two work-holding fixtures are used. Fast approach and return are at a constant speed of 300 in. per minute, which is unaffected by the cutting speed. Reverse can take place at any point in the stroke, control being by means of a dog on the table. A mechanical dead stop can be provided, so that plunge-cutting to fine limits can be performed. Automatic reversal after a pre-set time delay is possible.

TWO-DIMENSIONAL MILLING

Modifications of the basic machine enable it to operate on two-dimensional work. In this form it is known as the " Centec 3R." Hydraulic operation of the cutter-spindle head in a vertical plane, coupled with similar operation of the table in a horizontal plane, makes it possible for the machine to work to a programme consisting of any number and any combination of horizontal and vertical movements. Vertical movement of the spindle head is controlled in the same way as the table feed and traverse. A solenoid pilot valve provides a fast vertical approach of the spindle, followed by a steplessly-variable pre-set feed. The spindle can be fed down to six different levels, which can be pre-determined automatically and are controlled by positive stops. Rapid traverse is over 300 in. per minute and the vertical feed rate is from $\frac{3}{4}$ in. to 36 in. per minute. Setting of the operating cycle is by means of adjustable buttons sliding in slots, no cams being used, and the complete control slide can be removed if required without disturbing the button setting. It is thus possible to machine a batch of components and then remove the control slide and store it until it is needed for the next batch. Only the fixtures need re-positioning, and the machine is then ready for operation automatically as before. The control slide and operating dogs are covered by a streamlined guard when the machine is operating automatically, and it is thus impossible for swarf to fall on to the controls and interfere with the cycle.

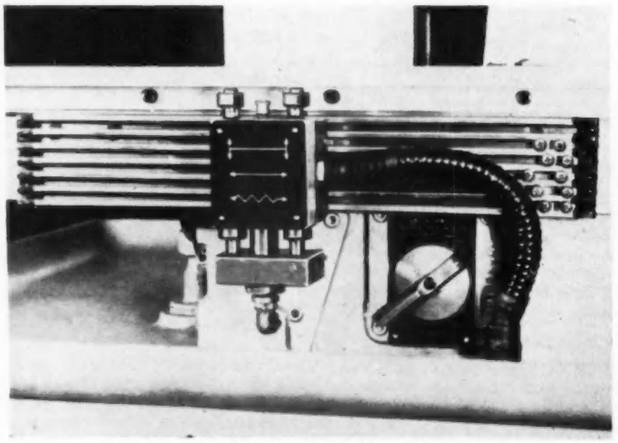
The number of automatic cycles which can be set on this two-dimensional version of the machine is obviously very large. The machine can, for example, carry out vertical and horizontal milling of two or more faces on the same component, mill on three planes successively, work between or over fixtures and carry out pendulum milling with two fixtures. Many other applications of the automatic cycle are possible, and the availability, as an extra fitment, of a vertical milling head, increases the range.

OPERATION WITH INDEXING FIXTURES

The addition of a " Centec " auto-pneumatic indexing table, mounted directly on the machine table or on angle brackets, according to the nature of the work to be done, increases the range of the machine still further, and more than one of the indexing tables can be used in some work cycles. Two indexing tables mounted directly on the machine table, for example, can be used for milling, with two ordinary side and face cutters set at the required spacing on the spindle, squares on the ends of round components. The automatic cycle is set to mill two flats on one component, rapid traverse to the next component, mill two flats there and then stop and index. The second two pairs of flats at right angles to the first are then cut in the same way, to form the squares. Another operating cycle, used in conjunction with two indexing tables, permits two different operations to be carried out on a component at a single setting. A clutch blank, for example, is carried on each of two indexing tables, which are mounted on angle brackets on the machine table. The machine spindle head reciprocates twelve times to perform the first operation on the twelve clutch teeth, as the indexing table moves through the correct angle to present the teeth in sequence. The table then moves across so that a second cutter on the arbor can perform the second operation on the teeth of the second component. Removal of the first component to the second operating position, and substitution of a fresh blank in the first position, enables the work to continue automatically.

A third version of the basic machine, the " Centec 3P," is arranged with a hydraulically-operated tracer valve for profile milling. The tracing system uses a patented valve which has a constant volume of oil through it in all operating positions, so eliminating the possibility of sticking due to periods of immobility. A machine equipped with the hydraulic tracer can work at angles up to 50 deg. from the horizontal, and can produce sharp corners. The system compensates automatically for any mechanical errors caused by deflections of components between the tracer valve and the main spindle, and it is possible to work to very close tolerances. Accuracy of reproduction to within 0·002 in. is easily maintained.

The " Centec " horizontal production milling machine has infinitely-variable speeds and feeds, and automatic control of the work cycles.



Cycle-setting is by adjustable buttons housed beneath a removable cover. The complete control slide can be removed and stored for re-use when on repeated production of small batches.

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GRAIN-HANDLING FILM

The part played by mechanical handling in the grain industry is the subject of a 16 mm. colour film with sound commentary entitled " The Seed is Sown," produced by the Mechanical Handling Engineers' Association. It has a running time of about 26 minutes, and is available on loan from the Association, 94–98 Petty France, London, S.W.1.

In Parliament

PROGRESS OF AUTOMATION

Technological development has been for many years a feature of Britain's economic life, and automation is the latest and most novel expression of that progress. As such, Mr. Iain Macleod, the Minister of Labour and National Service, told the House of Commons, automation was welcomed by the Government and responsible opinion on both sides of industry, as an essential factor of the nation's future efficiency and for the continuance of full employment. The anxiety that its introduction might cause was very natural and should be recognised. There were bound to be employment problems involving the transfer of labour and new skills would certainly be required.

These difficulties could be resolved satisfactorily if the Government and the two sides of industry worked in close co-operation with one another. It was essential that firms which were contemplating the introduction of automation should consider from the beginning how it would affect their workpeople and bring them into the discussions at an early stage of the planning arrangements. On their side, the Government accepted a continuing responsibility for maintaining the general level of demand. They would also help to meet the special effects which technological changes would have on the employment field, by making provision, as already announced, for a wide extension of technical education; by encouraging opportunities for training; and by assisting workers who had to change their employment. Discussions covering all aspects of the problem would take place, Mr. Macleod said, between himself and representatives of the employers, the trade unions and the nationalised industries, in the light of the report being published by the Department of Scientific and Industrial Research. If all concerned played their part, the new changes, which had unlimited possibilities for the future, would prove of immeasurable benefit to the nation.

GOVERNMENT'S RESPONSIBILITY

Mr. Will Owen (Labour) assured the Minister that trade unionists were no longer limited in their outlook to the philosophy of the Luddite movement, but welcomed the development of new techniques. At the same time, they were seriously concerned with the economic and social effects of the new machines, and earnestly desired early consultations between the two sides of industry, with Government co-operation. Mr. Ronald S. Russell (Conservative) inquired about the progress being made in the United States and was informed by Mr. Macleod that the Ministry of Labour had studied the experience and conclusions of other countries, but that these were not exactly applicable to this country. Britain must work out her own solutions, in the light of her own particular problems.

While acknowledging that Mr. Macleod's statement was encouraging, Mr. Frederick Lee (Labour) urged that the Government should issue a considered statement of policy. Mr. George Brown (Labour) asked for an indication that the Government were planning to have jobs available for men affected by automation, and new houses for them if they had to move away from their homes. Mr. Macleod said that the Government recognised their responsibility. It was precisely these problems which were engaging their attention.

EQUAL PAY IN ENGINEERING

Later, Mr. Lee asked the Minister of Labour if he would reconsider his decision not to hold an inquiry into the rates of pay for women employed in the engineering industry. Mr. Macleod replied that he was happy to accept the view that his Ministry was "a sort of neutral court" to which both sides of industry might appeal when they were in a great difficulty and he agreed that the problem of equal pay in the engineering industry was an important and serious national issue. At the same time, he felt that a court of inquiry was the last resort in the hands of the Minister and it was one which was used extremely rarely. As he had informed the trade unions concerned on April 26, a court of inquiry seemed to him wholly inappropriate for the sort of detailed investigations which would be involved.

Mr. Macleod agreed with Miss Jennie Lee (Labour) that it would be disastrous if there were a major strike in the engineering industry, but, he said, the question of which was the best way to resolve the problem of equal pay was a purely practical issue. A court of inquiry did not seem the proper body. Indeed, since receiving his letter, the unions had asked the employers' Federation whether it would meet to discuss the possibility of instituting an inquiry within the industry itself.

DUSTS AND DISEASE

In reply to Sir Ian Horobin (Conservative), who asked about recent medical and technological research into byssinosis, Mr. Robert Carr, Parliamentary Secretary to the Ministry of Labour and National Service, said that his Ministry had been in the closest touch with recent developments and was aware of the dust-extraction appliance devised by the Shirley Research Institute, which was now being tested at the Monarch Mill at Oldham. The research into both the medical and technological aspects was continuing. On the technological side, the latest reports showed that this appliance represented a great advance and the Ministry was associating itself with the work by making further detailed dust estimations.

Asked if he would ensure that no time was lost in spreading the use of the new appliance throughout industry, Mr. Carr said that tests appeared to show that this apparatus was giving extremely good results. Two other appliances, based on different principles, had also been devised, however, and the value of these had still to be determined. The Government were arranging to conduct detailed tests, in order to compile records and to compare the three methods. Mr. Tom Brown (Labour) desired the Minister to call the attention of managements and factory inspectors to the new devices and to recommend that they should be installed wherever there was excessive dust. Mr. Carr said he would certainly see that managements and inspectors were informed.

Fuel Research Station, Stevenage

Building work on the new accommodation at Stevenage for the Fuel Research Station of the Department of Scientific and Industrial Research will be commenced next year, according to a reply by Mr. Patrick Buchan-Hepburn, the Minister of Works, to Mr. Arthur Skeffington (Labour). It was intended that the first part of the new structure should be completed about three years later. No date had been fixed for starting on the second part of the project.

Fisheries Research Vessel

Research work from the fisheries research vessel Explorer started at the beginning of this month, Mr. J. Henderson Stewart, Joint Parliamentary Under Secretary of State to the Scottish Office, told Mr. Hector Hughes (Labour). The vessel was taken over from the shipbuilders on March 30 and would be used principally for the collection of information about stocks of fish, their movements and surroundings. These particulars were needed for the study of fish conservation and kindred problems. It was a long-term process, Mr. Stewart said, and he did not think that the House would be interested in too frequent reports.

Forth Tube Crossing

Asked by Major W. J. Anstruther-Gray (Conservative) whether the report of the panel of experts on the merits of the Forth tube crossing had now been examined, Mr. Stewart said that there was nothing further to report at the moment. There would be no unnecessary delay but the Scottish Office could not move further in the matter until it had received replies from the local authorities concerned.

Technical Education in Scotland

Mr. G. M. Thomson (Labour) inquired whether any changes were proposed in either the extent or the timing of the suggested expansion of Scottish technical education announced in the White Paper on *Technical Education* (Cmd. 9703). He was informed by Mr. Stewart that, in view of the urgency and importance of extending technical education, the review of expenditure for the financial year 1956-57 proposed by the Chancellor of the Exchequer in the Budget debate would not apply to the Government's plans recently announced in the White Paper. Local authorities had been aware of this for a very long time.

Future of the D.S.I.R.

Mr. J. R. Bevins, Parliamentary Secretary to the Ministry of Works, stated, in reply to Mr. E. G. M. Fletcher (Labour), that the recommendations contained in the interim report of the Jephcott committee of inquiry into the D.S.I.R. had already been published as a White Paper. They formed the basis of the main provisions of the Department of Scientific and Industrial Research Bill, which had passed through all its stages in the House of Lords and had since been introduced into the House of Commons. The committee's final report did not make positive recommendations for immediate action, but contained a number of suggestions for the consideration of the new research council which it was proposed to set up under the Bill. The final report would not be published because it was quite clearly a report containing suggestions for the consideration of the new council, when formed.

Steel Supplies Improve

Captain Peter Thorneycroft, the President of the Board of Trade, informed Mr. Maurice Edelman (Labour) that, according to estimates by the Iron and Steel Board, supplies of steel from British producers to the steel-using industries in this country should increase during the present year by about 10 per cent. on the level attained in 1955. Demands upon Britain's steel industry comprised not only inland consumption but exports to all overseas markets, and included any increased opportunities which might have been secured in Russia. However, exporting industries in Britain should benefit substantially from the anticipated increase in production. Captain Thorneycroft agreed with Mr. Paul Williams (Conservative) that a number of British industries, and especially the shipbuilding industry, were still short of steel. He was in constant touch with the Iron and Steel Board in that connection.

Need to Study Canadian Preferences

In another reply to Mr. Williams, Captain Thorneycroft said that considerable publicity had been given to the recent statements of Mr. A. R. W. Low, Minister of State to the Board of Trade, on the subject of exports to Canada. The Minister had emphasised the importance of making prompt deliveries and of adapting British designs to Canadian tastes, and the Board of Trade was constantly bringing these matters to the attention of individual firms and trade associations. It was often the case that the failings of a few individuals gave a bad reputation, when the general level of performance was very high.

Radioactive Waste in River Thames

The principal discharges of radioactive waste into the Thames come from establishments of the United Kingdom Atomic Energy Authority, according to a statement by Mr. Duncan Sandys, the Minister of Housing and Local Government. He told Dr. Somerville Hastings (Labour) that safe limits for the radioactivity in these discharges were defined in authorisations issued under the Atomic Energy Authority Act, 1954. The radioactivity was well below the total permitted.

THE HUMAN ELEMENT

Standards, automation and prosperity—Community consciousness in South Wales—Trade union developments in the printing industry—From managers into company directors—Left-wing ascendency in a transport union—Maintaining a professional status in the face of tax demands.

★ ★ ★

The Engineering Unions and Automation

The strike at Standards has been settled and consultations will now be taking place to find a way out of the difficult problem of redundancy. The strike has done more to focus world-wide attention on the impact of automation on industrial Britain than seemed possible, since automation was not the basic issue. As we go to Press a three-year study by D.S.I.R. will have been published dealing with the technical and social problems of automation. Opinion varies widely concerning the speed at which electronic controls will intrude on traditional production techniques. Sir Vincent Tewson, General Secretary of the T.U.C.—58 last birthday—said "I do not think I shall see in my lifetime 10 per cent. of British industry run by the push-button." Many will agree with him; the workers most likely to be affected are those who operate machines in factories organised on mass-production lines. Few processes can be made automatic if the products are tailor-made in small numbers. By American standards the majority of British engineering factories could be classified as jobbing shops, including a good many in the motor industry.

But the field for the introduction of automatic processes is none the less a very large one. Cars, refrigerators, household appliances of all types, small prime movers, raw materials (including steel), and many engineering components could qualify if a saving in costs could be shown. Where a saving is made by introducing expensive new machinery with automatic controls in certain applications, there will be considerable economic pressure on managements to introduce a sufficient degree of standardisation in other applications to take advantage of the new techniques. This is how the process which, in the present industrial context looks like being slow, could gain momentum. The Government, the T.U.C., the A.E.U. and most of the other engineering unions are now busy planning for a smooth transmission from mass- to automatic-production. Re-training in new skills will be a major task. At present, however, redundancy is the main issue at Standards and elsewhere. The challenge to full employment does not come from automation, it arises from the apparent inability of British engineering to sell its goods competitively overseas. New production techniques could help; they are unlikely to hinder.

★ ★ ★

Two Welsh Pits Close

Two Glamorgan pits in South Wales are to be closed by the National Coal Board. The 1,065 men involved are already on a fortnight's notice. There is every evidence that the South-Western Division of the N.C.B. has been more than patient with the two collieries concerned. Lack of co-operation with management, go-slow movements and failure to fulfil promises freely given lie strewn across the history of these pits since the industry was nationalised. Financial losses amounted to £405,000 in 1955, from these pits alone. The men must now seek work in other valleys and, according to the local lodge of the National Union of Mineworkers, it will not be easy to do so.

This is more than a failure of two pits. It is the failure of a community. In many of the Welsh valleys even to-day, a development of this kind means a form of social disintegration and it points to a serious misapprehension somewhere of what makes a community of this kind a healthy social organism. Men as isolated as these must be, so far as the general labour market is concerned, do not endanger their livelihood (and they must have known to some extent what was coming) unless they are seized with some brand of economic and social hopelessness. The fact must be faced that the coal industry, for all its bold plans of investment and social consciousness at the centre, has at some of its fringes men at work whose economic attitude is that of a depressed and hopeless peasantry. To have travelled only from Grimethorpe to Glamorgan in a decade is a snail's pace indeed in industrial relations.

★ ★ ★

Strength Through Amalgamation

The settlement of the printing industry's dispute over wages after nine months of negotiation and of costly deadlock has been followed by a proposal to create a "National Union of Printing and Allied Trades Workers." The plans for the merger of the two largest printing unions—the National Union of Printing, Bookbinding and Paper Workers, and the National Society of Operative Printers and Assistants—were put forward last week by their general secretaries. They have invited the 14 other unions affiliated to the Printing and Kindred Trades Federation to join them in what would be among the seven or eight largest trade unions in the country. They argue that concerted action on wages affecting all types of employees would be much more likely to succeed.

Moreover, "Natsopa" and N.U.P.B.W. claim that they have an important membership of skilled men, in the case of the former amounting to one third of their 44,000 members, and in that of the latter to about one sixth of their 158,000 members. Both unions have rejected the proposal that there should be a two-tier system, one for craftsmen and the other for semi-skilled and unskilled workers for all wage negotiations in their industry. They consider that this would cut right across their membership and across the membership of practically every other union in P.K.T.F. Above all, however, the proposal to merge is designed to enable the unions to handle on an industry-wide basis, problems that may arise following the introduction of automatic processes in the industry.

The impact of automatic techniques on trade union organisation will certainly lead to changes in the patterns that have evolved but not altered radically for over a century. A three-year agreement was signed last week between the three unions concerned with process engraving and the employers, setting up a joint consultative committee "to provide for the introduction of new techniques and methods." This tendency towards the re-organisation of trade unions into industry groups, irrespective of trades and skills, is spreading throughout industry. As it spreads it will not only alter organisational patterns, but the fundamental attitude of workers to machines and to employers. "Sharing the benefits of automation" is the new slogan.

★ ★ ★

Qualifying Shares for Directors

The decision of the board of Unilevers to dispense with qualifying shares for directors marks a milestone in what is often referred to as the managerial revolution. Many companies do not require such shares to be held by members of their board, but the fact strikes home when one of the giants of trade and industry takes such a step. It is a mixed blessing. Directors are by tradition men with a sizeable interest in a company who take the top decisions and the big risks. As important shareholders they are expected to take the short-term fluctuations on their incomes. Because their own money is involved, they are presumed to steer a right course between undue circumspection and foolhardiness.

To-day, a type of professional director has arrived who is expected to plan long-term policy for the company by reason of experience, professional qualifications and so on. He may get substantial fees for this. He may get an expense allowance. He may get a salary and fees. The new model has one great advantage. Managers can thereby graduate on to the board. In an age when capital accumulation is a difficult task, and hence the acquisition of shares at a reasonably rapid rate in sufficient quantities is a difficult undertaking, the good engineer, or whatever he may be, can thus get to the top. Mixed boards consisting partly of the old type and partly of the new type of director are common enough. There is much to be said for getting the best of both worlds. This applies not only to mixing the types on the boards but also to making all directors, wherever possible, gradually assume some shareholding over a period of time. The realisation that he is risking his own money cannot but help a man's concentration wonderfully at a board meeting.

★ ★ ★

From Right to Left in T.G.W.U.

The election of Mr. Frank Cousins as general secretary of the Transport and General Workers Union represents a major break with tradition. Ernest Bevin, Arthur Deakin and also A. E. Tiffin had stood firmly and emphatically on the right of the labour movement. They had carried their union, the largest and most powerful in the movement, quite decisively into the fray whenever major disputes have broken out between right and left in the Labour Party. Mr. Cousins is most unlikely to oppose and abuse Mr. Bevan in the way Mr. Deakin did. He is much more likely to take up the role of peacemaker between the two extremes. Mr. Cousins is definitely and consciously on the left of the Labour movement. Now that he has been elected by a big majority Mr. Cousins may well make one of his main objectives the bridging of the gap between the majority of the union leaders and the majority of the constituency parties.

This has taken place at a time when the left is gaining ground among trade union leadership. Major issues are facing organised labour. This year or next may well see the first real challenge to full employment since the war. Redundancy, short-time, automation, restrictive practices, differentials and major issues concerning the future of nationalised industries are likely to give Mr. Cousins a great deal to think about. His intervention and his influence on his colleagues in other unions may prove a decisive factor in shaping the Labour policy in the next few years.

★ ★ ★

Professional Remuneration

An address called "The Plight of Professional Engineers" was given by Mr. J. H. W. Turner to the south-eastern branch of the Engineers' Guild last week. Pointing out that the engineer is the ideas man in industry, he said that there is no incentive for the professional engineer to exert himself. On the contrary, the engineer working as a professional man on fees is distracted by financial worries. "Before the war," Mr. Turner said, "a professional engineer might earn between £750 and £2,000 per annum. If he were on the same basis to-day he would have to get between £2,500 and £15,000 a year."

It is important, however, to emphasise that it is not so much the earning power of the professional man which is limited. Because of the high rate of taxation to-day it often pays a senior partner to sit tight and not expand his business, and such a climate is good neither for the man concerned nor for the younger men with him, for they need to find increasing outlets for their talents if they are to stay in professional work. Only tax relief can provide the solution.

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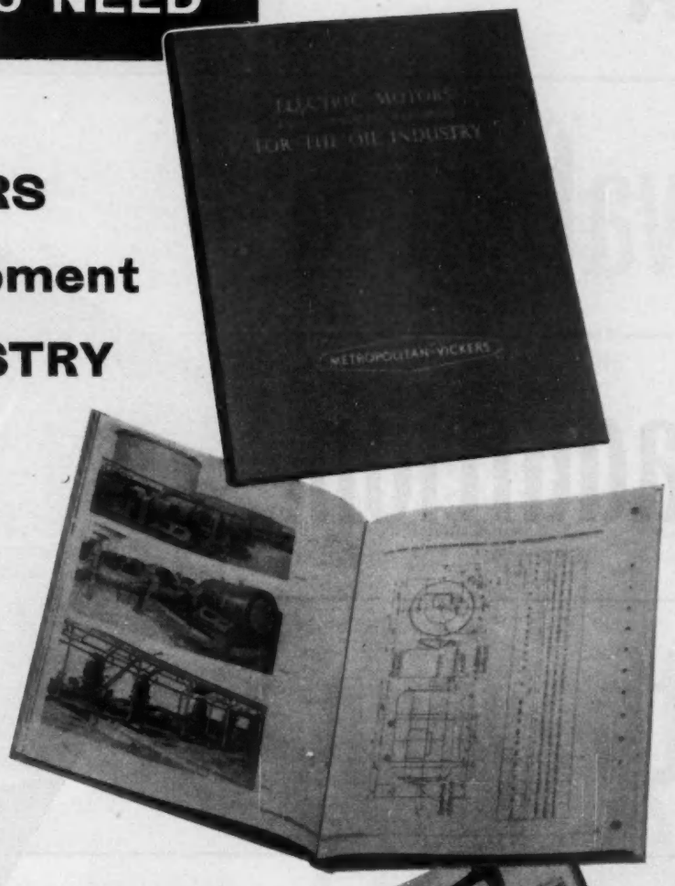

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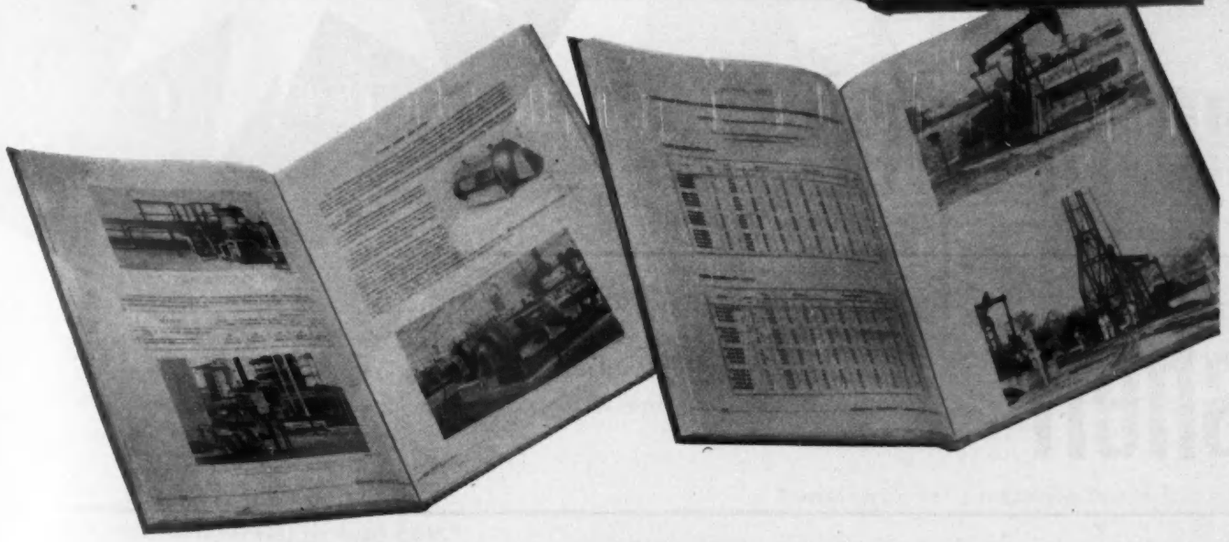

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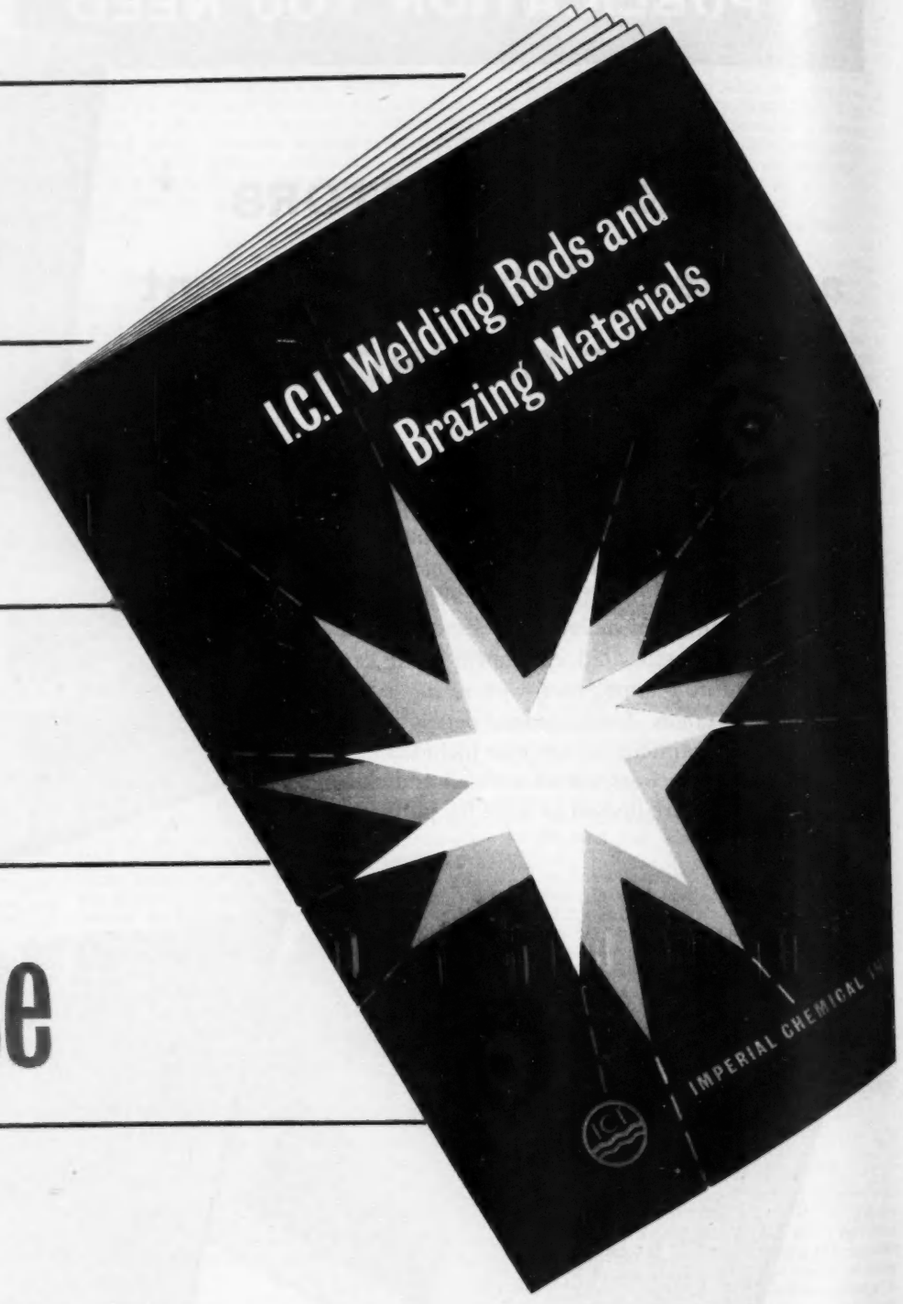

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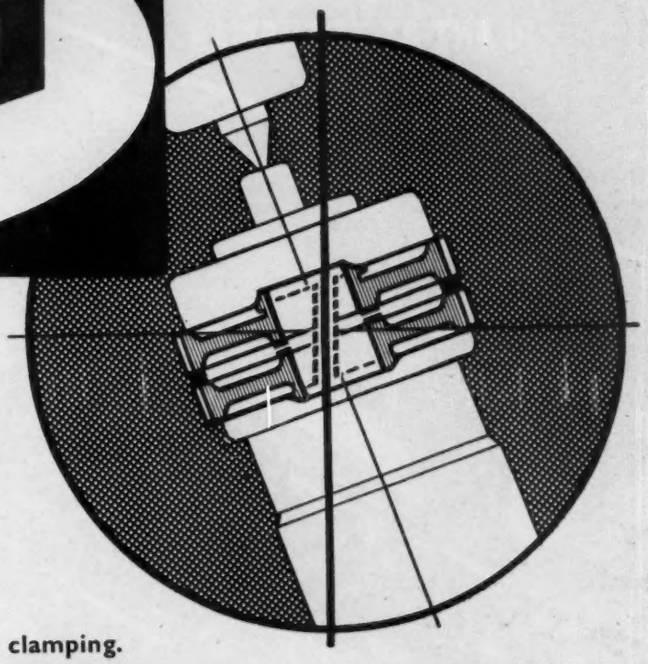

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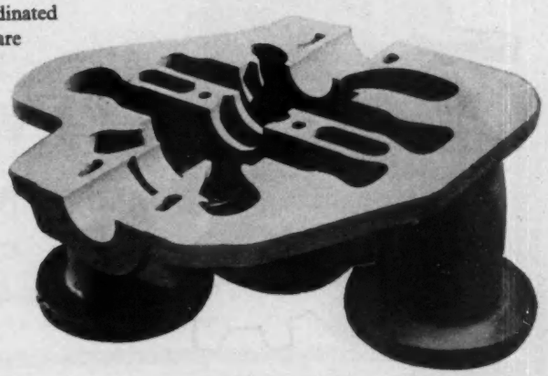

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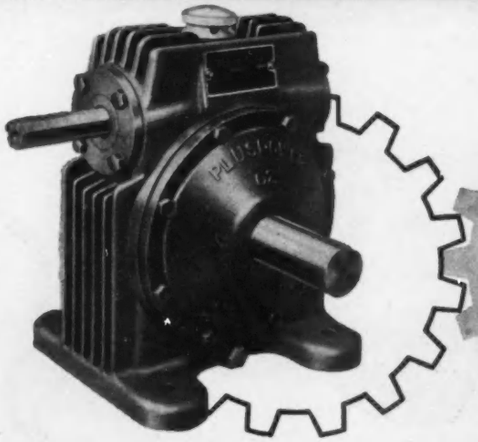

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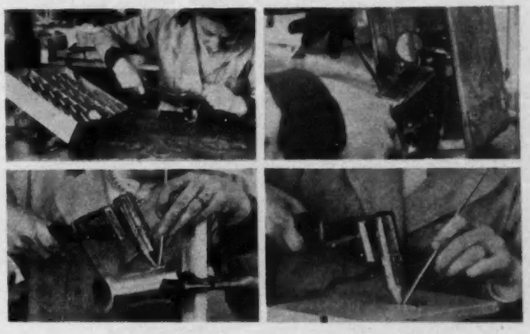

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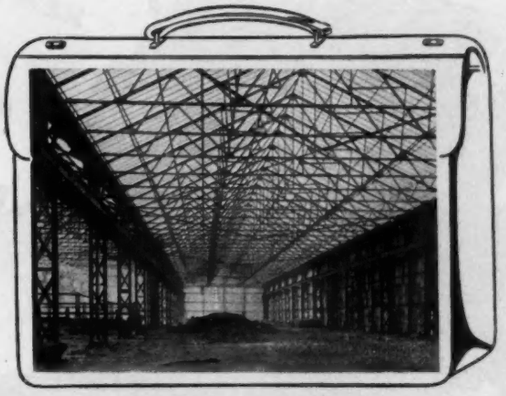

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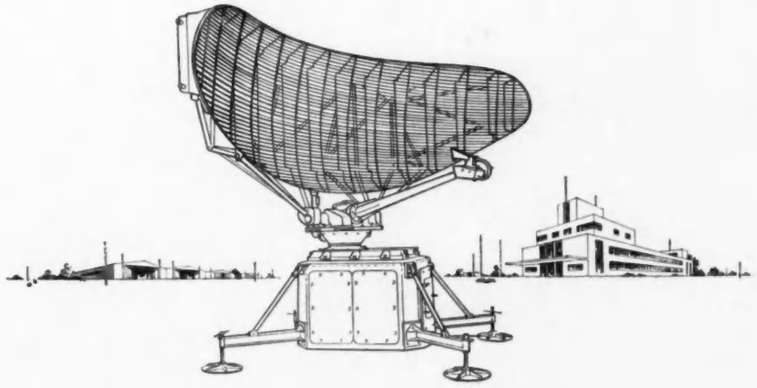

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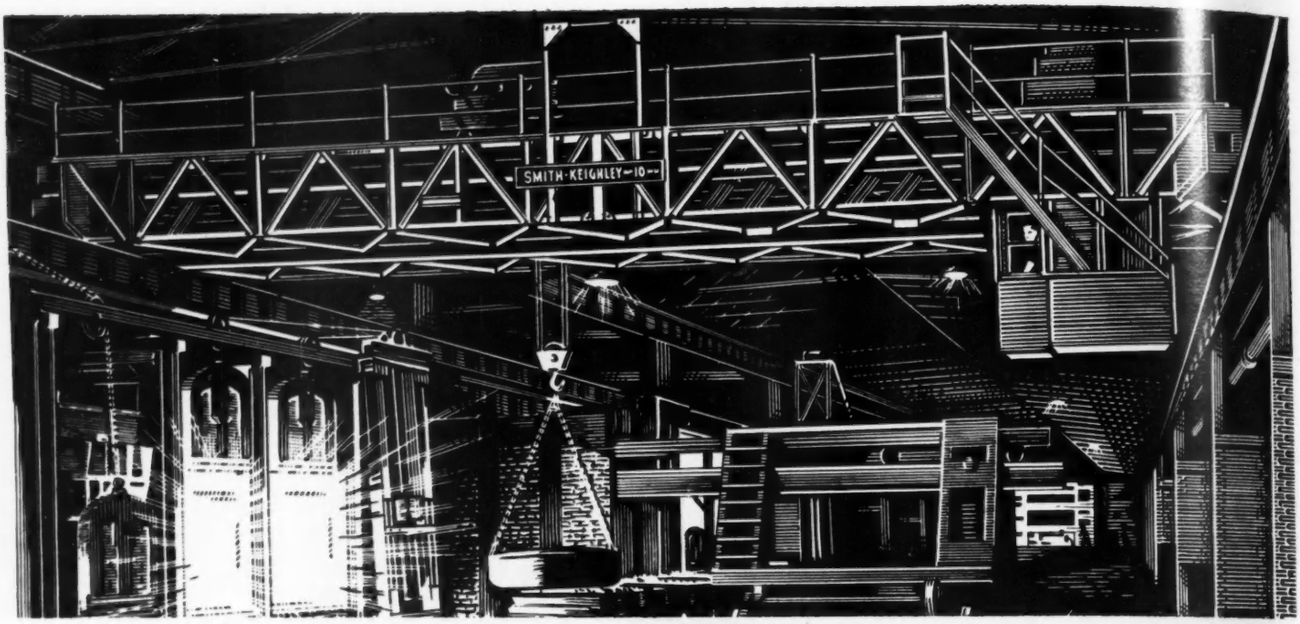

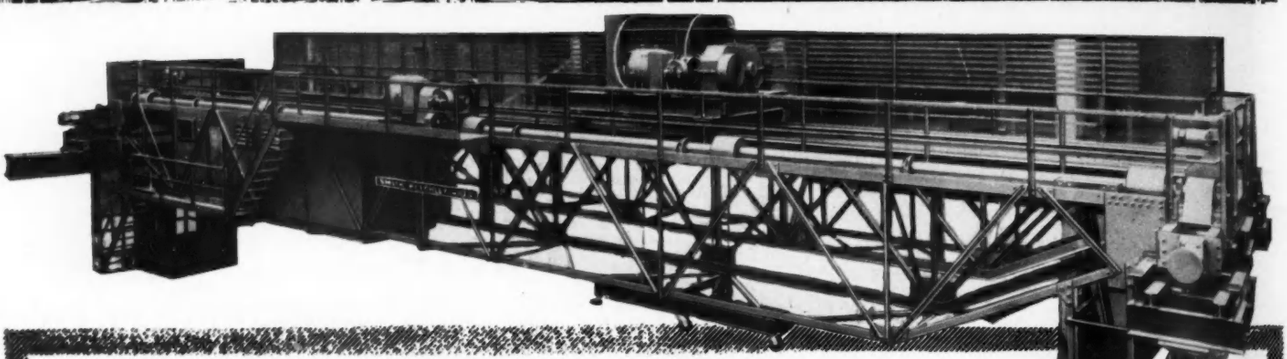

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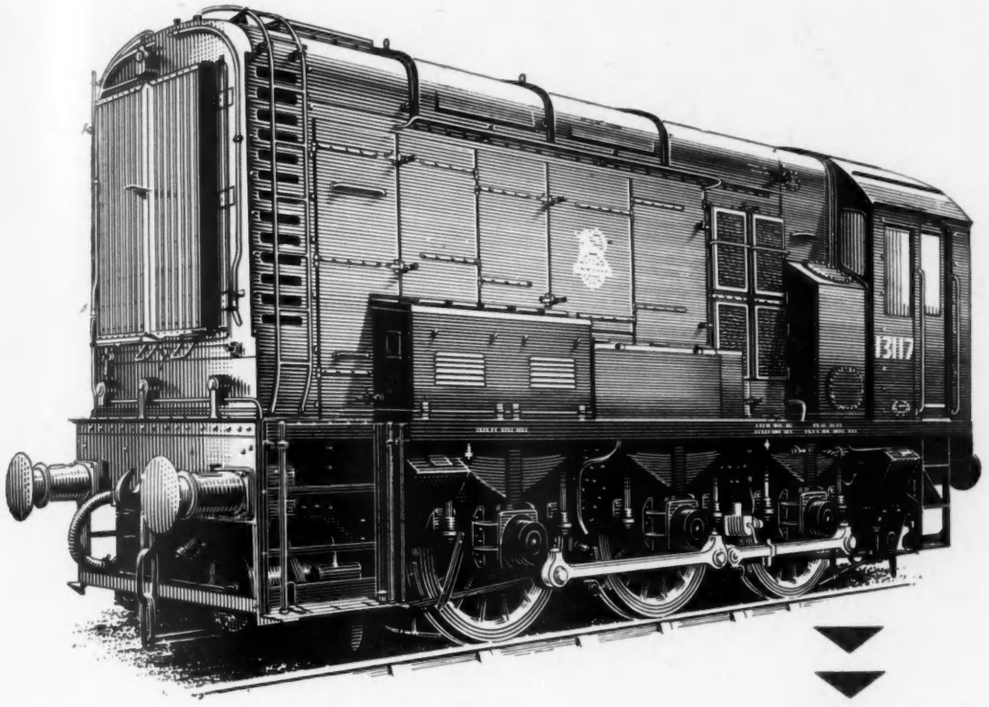
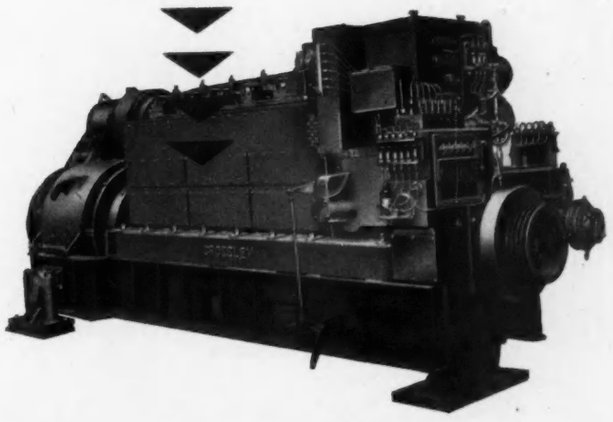


DIESEL ELECTRIC SHUNTERS

Employed with conspicuous success in large numbers of diesel-mechanical shunters, the Crossley straight-line Scavenge Pump Diesel Engine is now applied to diesel-electric operation in ten standard British Railways 0-6-0 shunting locomotives.

As prime mover of the power unit, for which Messrs Crompton Parkinson Ltd. were the main contractors, the compact six-cylinder "EST" type engine has a continuous rating of 350 b.h.p. at 825 r.p.m. and provides a maximum tractive effort of 35,000 lb.



CROSSLEY DIESEL ENGINES

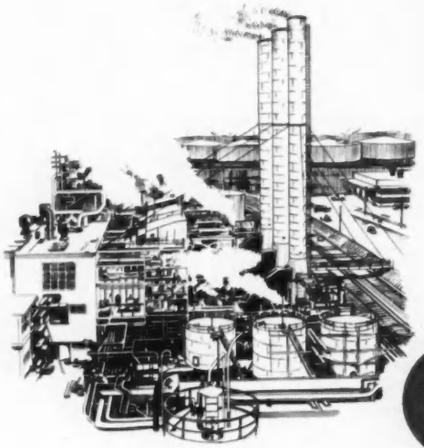
CROSSLEY BROTHERS LIMITED · OPENSHAW · MANCHESTER 11.

LONDON OFFICE: Langham House, 305 Regent Street W.1

C.194

Under One Responsibility

CJB



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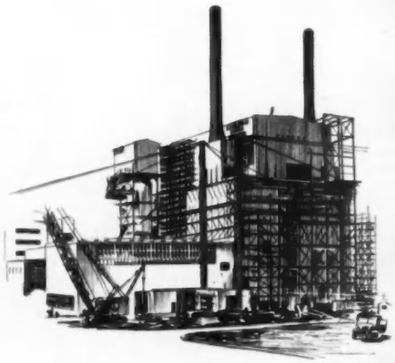
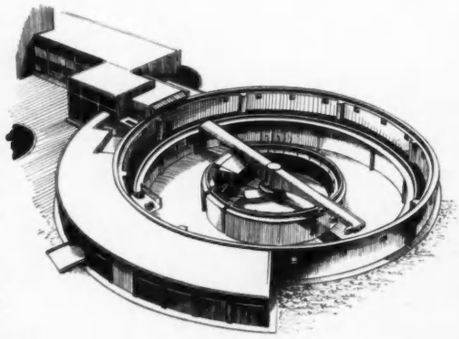
. . . is offered, as a whole or in part, to meet the particular requests of the client.

The integration of all engineering activities within a single contract permits rapid and efficient working between specialist departments and the closest co-operation with the client.

Our organisation and experience has covered a wide field including oil refineries, chemical plants, pipelines and research projects for Government Departments both in the United Kingdom and overseas.



CALDER HALL
(United Kingdom Atomic Energy Authority)



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COSTAIN-JOHN BROWN LIMITED

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Phone: GROSVENOR 4181 & 8331. Cables: CIVANIC, LONDON.

THE LATEST DESIGN IN MODERN LIGHTWEIGHT AIR COMPRESSOR PLANT
"BROOMWADE"
363 SAS

12,000 miles apart but . . . .

. . . the JOHN THOMPSON GROUP, with its world-wide ramifications, is a working team, supplying steam generating plant to fast-growing Australian industry today as it has to British industry since 1839. A long tradition of continuous research and experience has made John Thompson Water Tube Boilers the recognized name in high efficiency steam production on five continents.

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FLEXADUX REGD. Collapsible, Flexible Ducting

DUX. 3

FLEXADUX has won enthusiastic acceptance in the factories, mines and quarries of Europe. Now it is available in England to answer *your* ducting problems. It is easily stored, easily transported, easily assembled. The electrically welded construction gives smooth uninterrupted bore with minimum friction losses.

ABRIDGED DATA:

Composition. P.V.C. plastic, abrasion and acid resistant, rot-proof and non-combustible.
Pressure Limit. 20" water gauge.
Tensile Strength. 3,200 lbs./sq. in.
Type 'S'. Stiffened with external helical steel wire, totally enclosed in plastic to prevent corrosion. Suitable for both positive and negative pressures.
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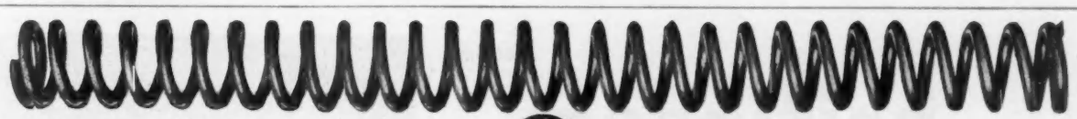
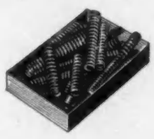
Standard Diameters. 8", 12", 16", 20" and 24" (Types 'S' and 'B'). 28" and 32" (Type 'S' only).

Can Flexadux be profitably applied to *your* operations? Linatex engineers will gladly survey your plant, make specific recommendations and supervise installations. For further information, call, write or 'phone:

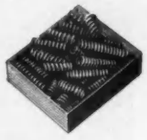
WILKINSON RUBBER
LINATEX LTD
CAMBERLEY SURREY
TELEPHONE: CAMBERLEY 1595



No. 1013. 1 gross Small Coil Compression Springs, ½" to 1½" long, 3/32" to 7/16" diam., 24G to 19G. 6/- each

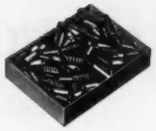


No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6 each.



No. 98A. 3 doz. Assorted 1" to 4" long. ½" to ¾" diam. 19G to 15G. 5/6 each

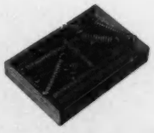
No. 757. Extra Light Compression. 1 gross Assorted. ½" to ¾", ½" to 2" long, 27 to 20 S.W.G. 15/- each.



No. 388. ¼ gross Assorted Small Expansion Springs. ¾" to 1¼", 18G to 21G. 9/6 each.

No. 466. ¼ gross Assorted Small Expansion Springs ¾" to 1¼" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.

No. 1024. 20 Compression Springs 12" long, ¼" to ½" diam. 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansions 1½" to 12" long, 5/32" to ¾" dia., 22G to 16G, 24/- each.



No. 753. 3 doz. Assorted Light Expansion ¼" to ¾" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.

No. 758. Fine Expansion Springs, 1 gross Assorted ¼" to ¾", ½" to 2" long, 27 to 20 S.W.G. 15/- each.

How are you off for Springs?

TERRY'S BOXES OF ASSORTED SPRINGS are just the job for your experimental department—a wonderful assortment of Compression and Expansion Springs... all sorts of lengths, gauges, diameters. The nine boxes we show are just a few from our range. Why not let us send you a full list—free?

TERRY'S

ASSORTED SPRINGS

These Boxes of Springs can also be obtained at:

LONDON 27 Holborn Viaduct
MANCHESTER 279 Deansgate
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The prices quoted are subject to the usual trade discount.

HERBERT TERRY & SONS LTD
REDDITCH, WORCS.

SPRING MAKERS FOR 100 YEARS

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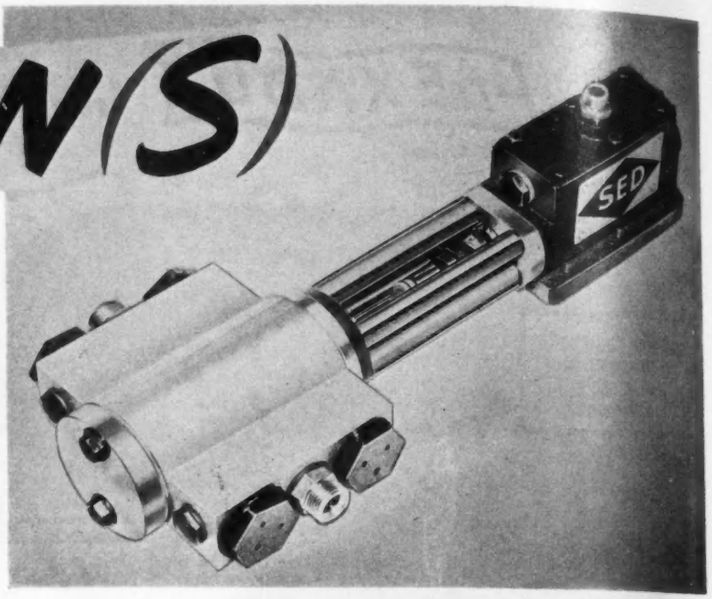
THIS IS NEW(S)



The S.E.D
'NEUMO' Mk. III
PNEUMATICALLY OPERATED PUMP UNIT

THE MOTOR

★ Two moving parts only.
★ Hardened and ground piston and valve.
★ Cast iron body with honed bore.
★ Non-stalling.
★ Negligible air consumption.
★ High power output.

THE PUMP

★ Double acting.
★ High efficiency.
★ Self-contained valves.
★ Easily serviced.
★ Pumps liquids up to 200 deg. F.

SIMPLICITY MEANS RELIABILITY

TYPICAL PERFORMANCE FIGURES

Air Pressure	60 lbs. P.S.I.	60 lbs. P.S.I.
Consumption	2½ Cu. F.P.M.	2½ Cu. F.P.M.
Delivery	45 gals. P.H.	120 gals. P.H.
Del. Pressure	30 lbs. P.S.I.	5 lbs. P.S.I.

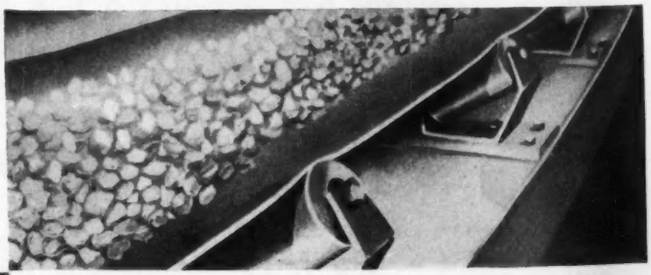
WIDE RANGE

Owing to the design and materials employed in its construction, the "Neumo" Mk. III Pump Unit is capable of handling a very wide range of materials such as paint at 200 deg. F., petrol, oils, from paraffin to high viscosities, Solvex, Mangersol, Basol, Trichlorethylene and all types of cellulose solvents, etc.

Send for further details to:—

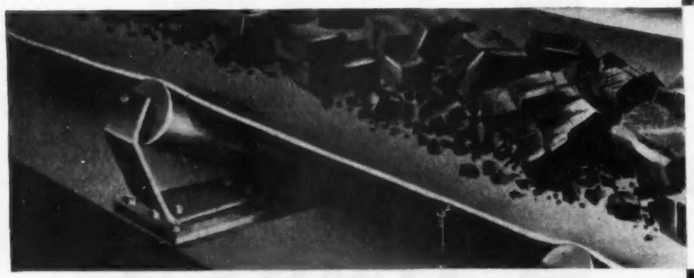
(Dept. EG), KINGSBOURNE PRODUCTS LTD., SOUTH COAST ROAD, PEACEHAVEN, SUSSEX **Tel. Peacehaven 2115**

Hot lime



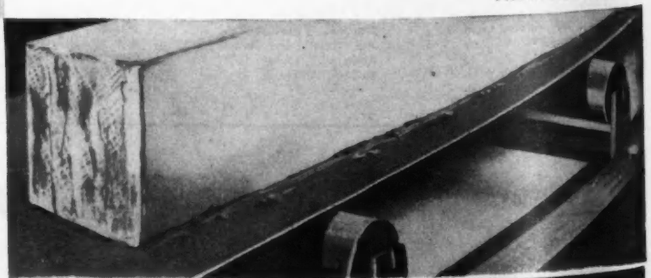
Whatever the material

Coal



to be conveyed . . .

Asbestos slabs



TURNERS
RUBBER CONVEYOR BELTING
is unequalled for . . .

TOUGHNESS, FLEXIBILITY and LONG LIFE

TURNER BROTHERS ASBESTOS CO. LTD.
ROCHDALE ENGLAND
A MEMBER OF THE TURNER & NEWALL ORGANISATION

C.B.1a

PLENTY
PUMPS

This advertisement is No. 11 of a series depicting well-known buildings with Plenty Pumps on the heating installations.

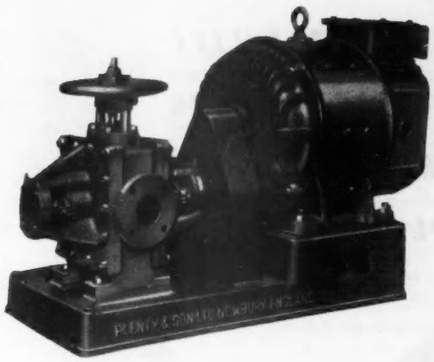


Illustration of a 60 gallons per minute, variable flow Plenty Pump, coupled to a flameproof motor.

View of Grosvenor House from the Park.

GROSVENOR HOUSE, Park Lane, London.

A single pressure pump supplying 100 gallons per hour of heavy fuel oil, at 200 lbs. per sq. inch, was supplied by Hubbard Combustion Ltd., in 1940. Plenty Pumps are available in all sizes from 60 gallons to 750 TONS per hour, in fixed or variable capacity.

Write for full details to

PLENTY & SON LTD., Newbury, Berks.

Telephone: NEWBURY 7. *Telegrams:* PLENTY, NEWBURY E.

For magnified output . . .

use mechanical tubing . . .

A great deal of time, labour and materials are saved when mechanical tubing is used, particularly when manufacturing rollers and ring-shaped machine parts.

We carry large stocks of tubing in many sizes and lengths with either large or small diameters. They are available in various finishes and are obtainable suitable for machining.

Write, 'phone or call for full particulars.

IMMEDIATE DELIVERY IN MOST CASES

Markland Scowcroft LIMITED

COX GREEN WORKS, BROMLEY CROSS, Nr. BOLTON

'Phone : EAGLEY 600 (5 lines)

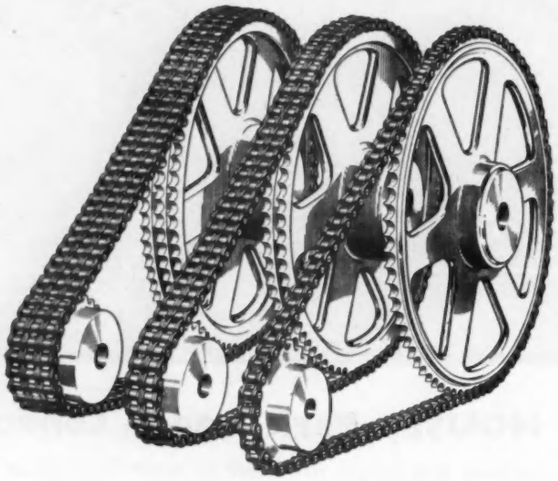
RENOLD

STANDARD STOCK SERIES

chain drives

FOR UP TO 140 H.P

PRECISION
RELIABILITY
ADAPTABILITY
SPACE SAVING
REDUCED COSTS
PLANNED OUTPUT



76 years' experience of precision chain manufacture is built into every Renold chain drive

RENOLD CHAINS LIMITED · MANCHESTER

Steam is a Raw Material....

it disappears in the course of production but its cost remains in the price of the product.

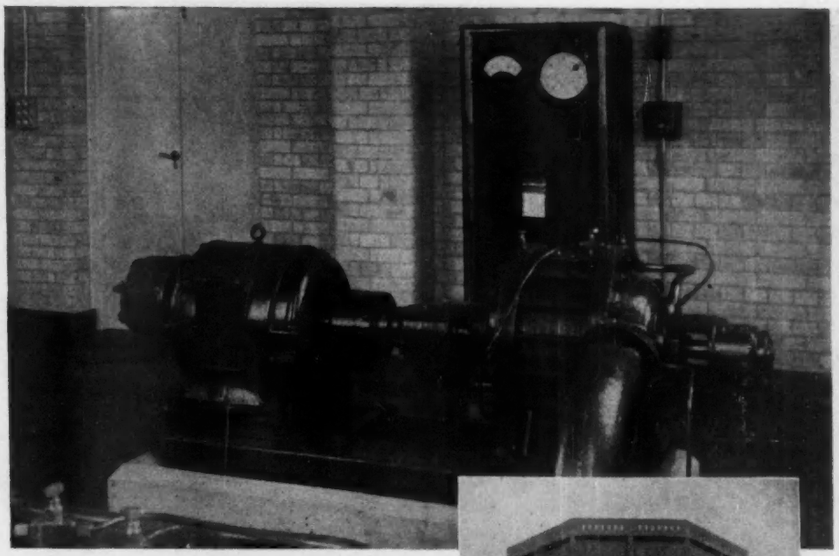
How much does steam cost you?

Consult your fuel distributor *or write for details of advisory services to:—*

NATIONAL INDUSTRIAL
N·I·F·E·S
FUEL EFFICIENCY SERVICE

Head Office: **71 Grosvenor Street London W1**
Telephone: Hyde Park 9706

THE LEVEL BEST....
remote indication and control equipment by EVERSHED



Yet another example of the successful operation of Evershed remote indication and control equipment is the recent installation at the Thingoe Rural District Council's Rushbrooke Pumping Station.

A telemeter water level transmitter is installed at the water tower and is connected by a two wire Post Office telephone line to the Pumping Station some four miles away, where a cubicle housing the level indicator, graphic water level recorder and pump control relay is situated. Adjustable high and low level contacts are provided on the pump control relay which operate an internally mounted power relay. The pump is thereby automatically controlled to maintain level in the water tower. The pump feeding the water tower draws its supply from a surface tank where the level is maintained by " Noflote " Control apparatus. Supply of water to this surface tank is provided by a borehole pump which is also controlled by " Noflote " apparatus.

Full details of Telemeter and " Noflote " equipment are available in Publications T283 and T234.

NOFLOTE TRADE MARK

EVERSHED & VIGNOLES LTD *ACTON LANE WORKS, LONDON, W.4*

Telephone: Chiswick 3670 • Telegrams: Megger, Chisk, London • Cables: Megger, London

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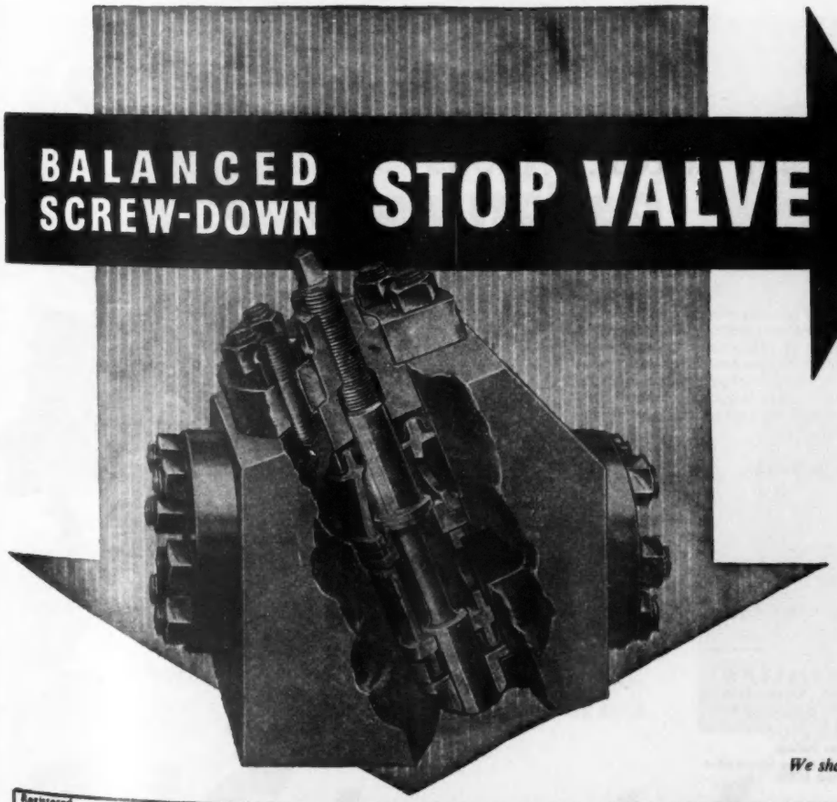
BALANCED SCREW-DOWN STOP VALVE

L.E.H.



The illustration shows the latest type of L.E.H. Balanced Screw-Down High-Pressure Stop Valve designed for operation in straight pipe lines; may be opened or closed against pressure.

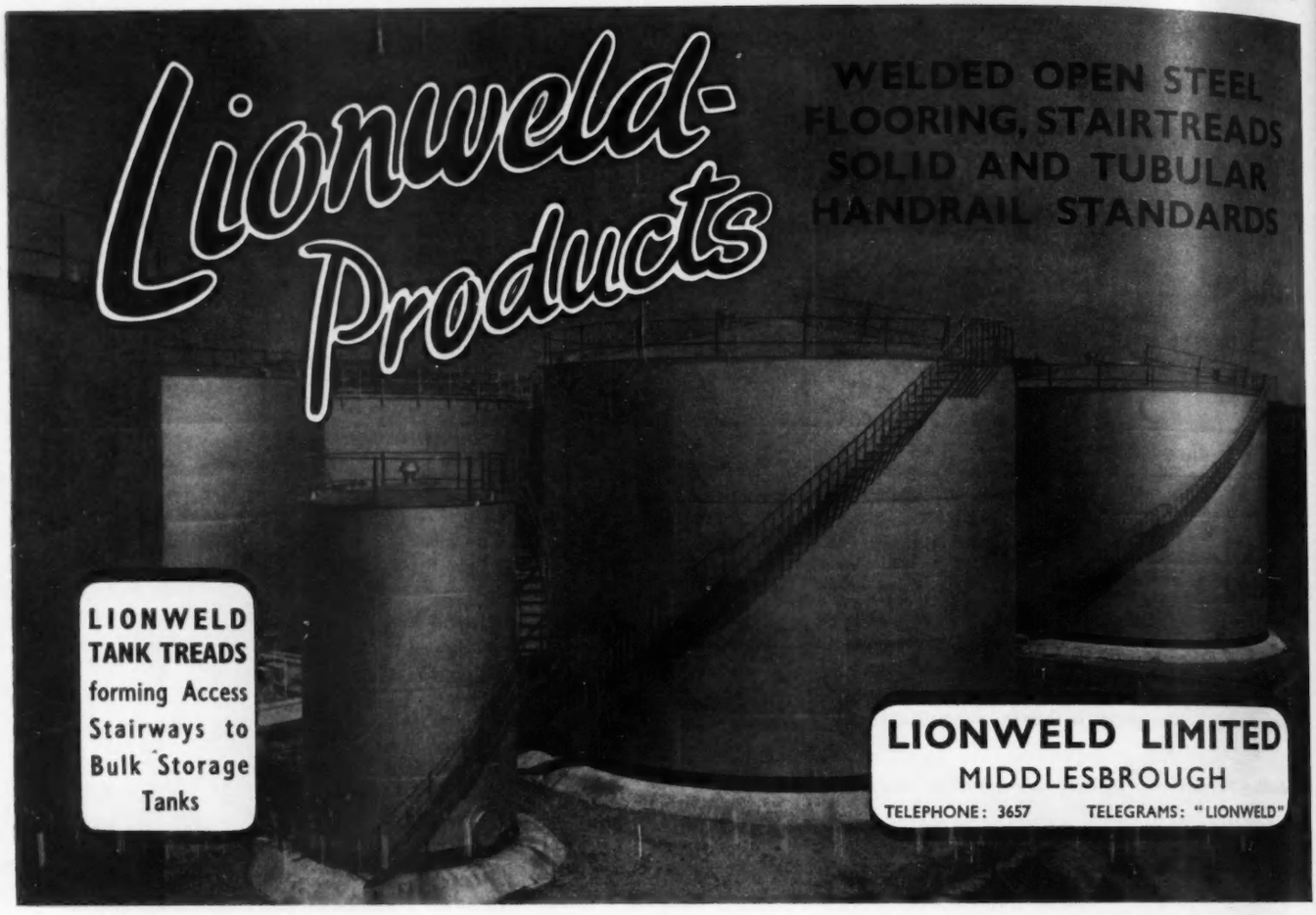
We also manufacture the following types of Hydraulic Valves—Piston Control Valves, Relief, Reducing and Unloading Valves for use with Hydraulic Pumps

We should be pleased to send fuller details on request.

Registered Trade Mark

THE LEEDS ENGINEERING & HYDRAULIC CO. LTD. • RODLEY • LEEDS

Telephone: Pudsey 2859 *Telegrams: PUMPS, RODLEY*


Lionweld-Products
WELDED OPEN STEEL FLOORING, STAIRTREADS SOLID AND TUBULAR HANDRAIL STANDARDS
LIONWELD TANK TREADS forming Access Stairways to Bulk Storage Tanks
LIONWELD LIMITED
MIDDLESBROUGH
TELEPHONE: 3657 TELEGRAMS: "LIONWELD"

BRABY are strategically placed . . .

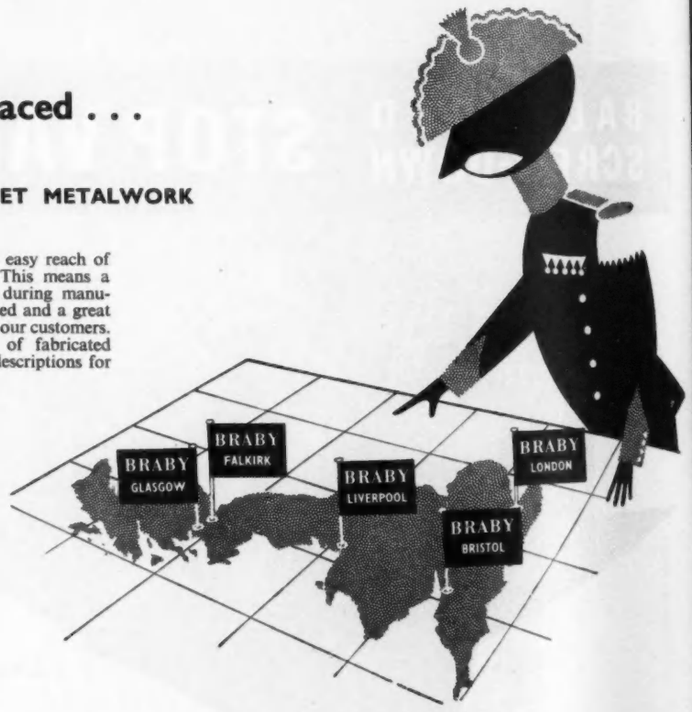
to supply industry with FABRICATED PLATE AND SHEET METALWORK

There is a **BRABY** factory within easy reach of every British industrial centre. This means a lot—closer contact is maintained during manufacture, transport problems are eased and a great deal of time and trouble is saved by our customers. Braby have been manufacturers of fabricated plate and sheet metalwork of all descriptions for more than 100 years.

We welcome your enquiries.

ONE OF THE WIDE RANGE OF
BRABY
PRODUCTS

Hot-dip galvanizing to the trade.



FREDERICK BRABY & COMPANY LIMITED
Head Office: 352-364 EUSTON ROAD, LONDON, N.W.1. TELEPHONE: EUSton 3456
FACTORIES AT: London Works, Thames Road, Crayford, Kent. TELEPHONE: Bexleyheath 7777
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Ashton Gate Works, Bristol, 3. TELEPHONE: Bristol 64041. And Falkirk
OTHER OFFICES: 110 Cannon Street, London, E.C.4 (Export). TELEPHONE: MANsion House 6034
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AP/004/133

Here is industry's most versatile ducting — SPIRATUBE. For mine ventilation or machine shop abrasives—for hydraulic rams or chemical fumes—factories, garages, tunnels, aircraft. There are special types of SPIRATUBE for almost every ducting need, in many coverings and sizes.

SPIRATUBE is fitted quickly and simply. You can do it yourself—there are no heavy hangers . . . no special elbows . . . no structural alterations. SPIRATUBE is available in diameters from 3 inches to 30 inches ready to serve you in any air or airborne job.

Write today for the SPIRATUBE booklet which illustrates what this versatile ducting will do. Put your problem up to our design engineers. They will be glad to advise you without cost or obligation. The address is Flexible Ducting Limited, Maryhill, Glasgow.

AN ASSOCIATE COMPANY OF GEORGE MACLELLAN & CO. LTD. ESTABLISHED 1870

FLEXIBLE DUCTING LIMITED, MARYHILL, GLASGOW, N.W,
Telephone: MARyhill 3729 Telegrams: Flexiduct,Glasgow, N.W.

Large quantities of
STEEL PLATES...
...can be readily
cut, punched or notched
With the BESCO UNIVERSAL DOUBLE END
PUNCHING, SHEARING, SECTION CROPPING & NOTCHING MACHINES (Type KSF 15)

Suitable for mounting on a concrete foundation block, or, as generally supplied, mounted on a four wheel truck for portable use in the shop or on outside sites. One shot lubricating system.

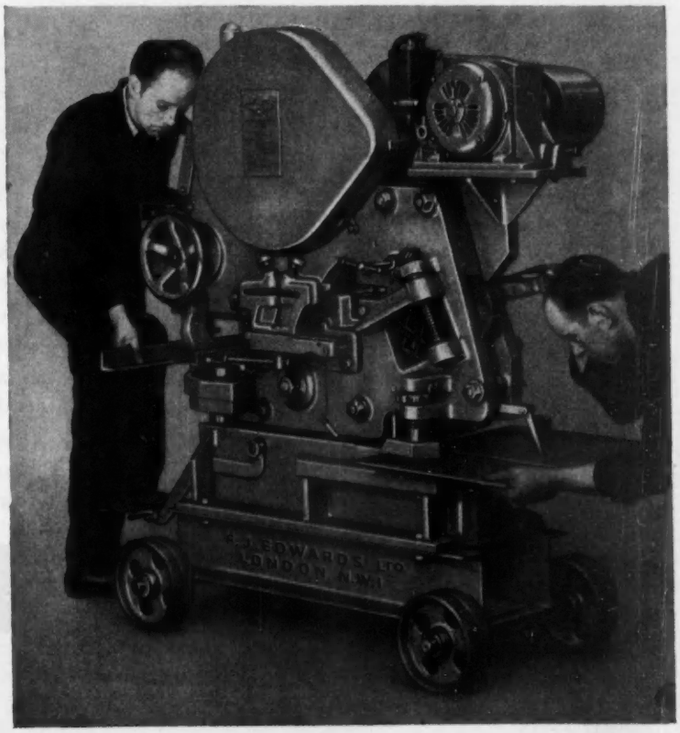
International MACHINE TOOL Exhibition OLYMPIA June 27-July 6
STAND No 214
EMPIRE HALL Ground Floor

ALL STEEL CONSTRUCTION
Unbreakable!

Capacities with the Standard tools supplied:

PLATE SHEAR	
Cuts plates any length or width up to	... ¾ in.
Flat bars up to	3 in. × ½ in.
Length of blades	... 9½ in.
SECTION CROPPER	
Angles at right angles up to	4 in. × 4 in. × ½ in.
Tees at right angles up to	4 in. × 4 in. × ½ in.
Rounds M.S.	... 1⅞ in. dia.
Squares M.S.	... 1⅜ in.
PUNCH	
Depth of gap	... 12 in.
Punches, M.S., max. for plates, angles, joists, etc.	⅞ in. dia. × ½ in. thick
NOTCHER	
Angles up to	2½ in. × 2½ in. × ½ in.
Plates up to	... ⅜ in. thick
Width of square notch	2⅛ in.

Model KS 9 cuts plates any length or width up to ⅝in. Model KSF13 up to ½ in. *Other sections in proportion.*



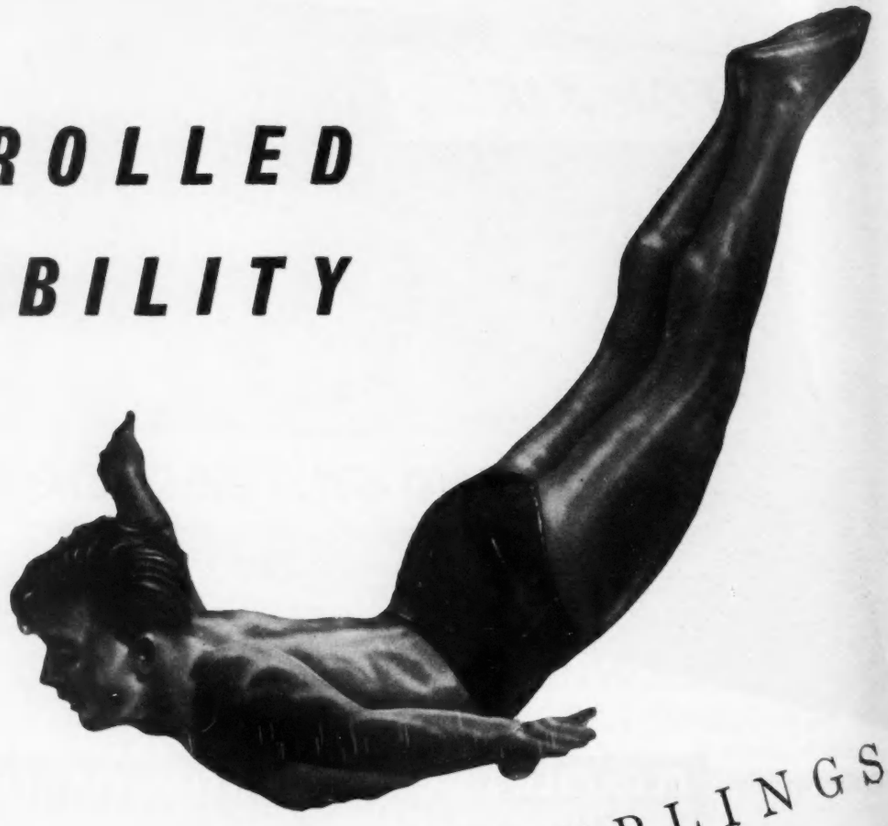
Registered Design No. 843793

F. J. Edwards Ltd

Edwards House, 359-361 Euston Rd., London, N.W.1
Telephones: EUSton 4681 (7 lines), 3771 (4 lines). Telegrams: Bescotools, Norwest, London

Lansdowne House, 41 Water St., Birmingham, 3
Telephones: CENtral 7606-7 Telegrams: Bescotools, Birmingham, 3

CONTROLLED FLEXIBILITY



CUSHIONED DRIVE COUPLINGS

THE perfectly functioning flexibility of an athlete's muscles, co-ordinated to meet every strain and effort are reflected in Silentbloc Couplings.

In the Cushioned Drive type specially designed and pre-loaded rubber elements give controlled flexibility under the fluctuating loads of changing power thrusts, torsional vibration and angular misalignment.

Compactly designed for comparatively high horse powers and maximum speeds—from 2 to 12,500 h.p. at 100 r.p.m. Easily assembled, needs no lubrication and is impregnable to water, dirt and atmosphere.

Almost certainly there is the correct coupling for *your* needs in the standard range ; if not a special Silentbloc Coupling will be made for you. Write us for further details.

SILENTBLOC

SILENTBLOC LIMITED • MANOR ROYAL • CRAWLEY • SUSSEX • TEL. CRAWLEY 2100

Jill, Joan, June, Jane and Jezebel— take five letters to my five welding suppliers

Tired of crossed letters, crossed wires and crosstalk? Clearing the snags on an automatic welding production line—and getting different answers from too many suppliers?

You'll find Quasi-Arc talk your language. A single number—Bilston 41905—on your telephone.

Quasi-Arc Limited are the only people in the arc welding business who make and sell *everything*. They can quickly provide you with manual and automatic welding equipment, installations and supplies—everything you need, including sound technical advice. You will find them thoroughly equipped for service and research.

So send away all the girls but Jezebel. Dictate a letter to Quasi-Arc. They can deliver the goods.

The interests and activities of The Quasi-Arc Company Limited and Fusarc Limited in the well-known processes

Quasi-Arc · Fusarc · Unionmelt · Sigma
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have been combined in order to provide a thoroughly comprehensive and effective service to the welding industry. The headquarters of the new organisation—named Quasi-Arc Limited—are at Bilston, Staffordshire, with works at Bilston and Gateshead.

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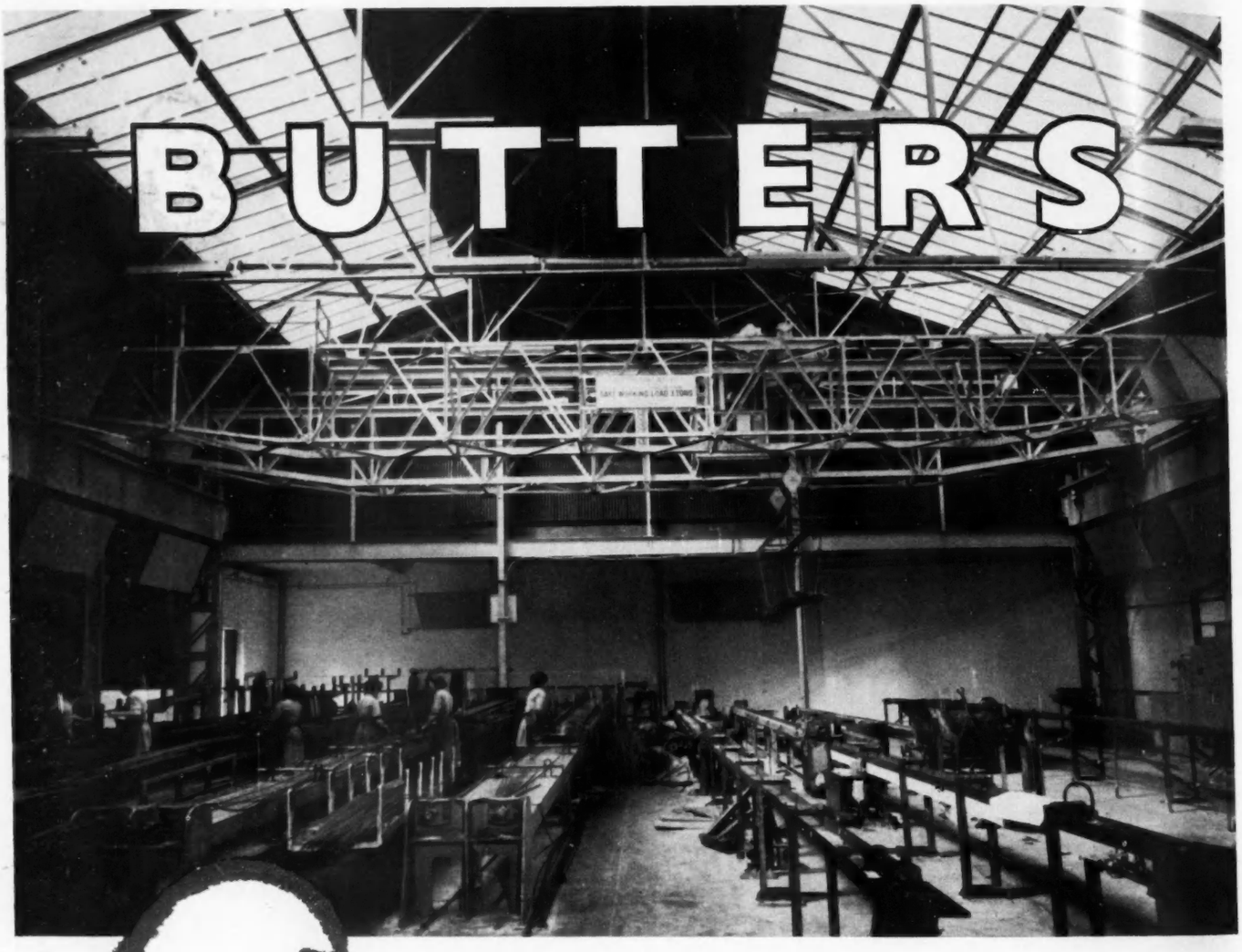

Aluminium Alloy Main Girder

Overhead Cranes

are made in powers and sizes to meet all requirements. The crane shown is a 3 ton electric travelling model with a span of 69 ft. 3 in. It is unusual in that the main girder is constructed of aluminium alloy, supplied by Messrs. James Booth for whom the crane was built.

We shall be pleased to prepare quotations against requirements.

Photograph by courtesy of
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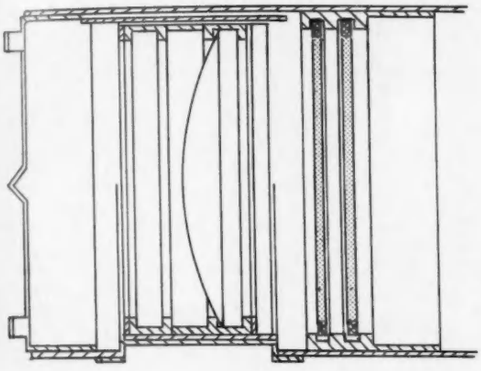

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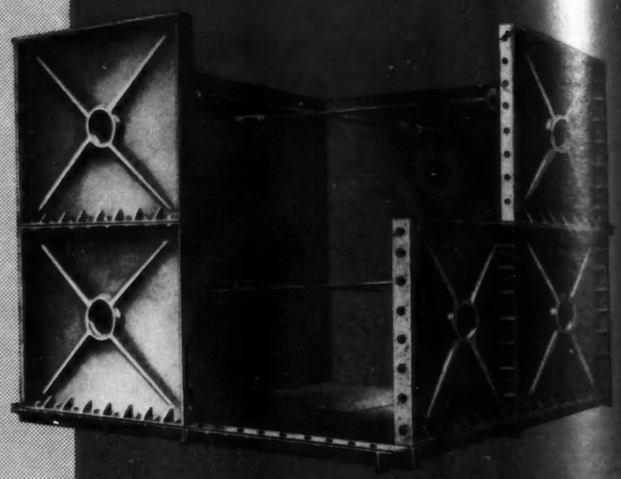
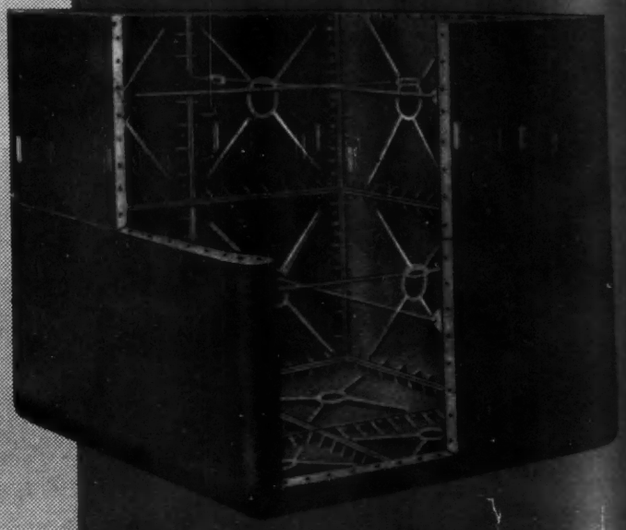


Standard Cast Iron Tank with external flanges (For capacities see table)



Standard Cast Iron Tank with external flanges

CAPACITIES OF EXTERNAL FLANGED TANKS MADE FROM STANDARD SQUARE 4 FEET PLATES

TANK SIZE	DEPTH 4 FEET		DEPTH 8 FEET	
Length by breadth	Approx. total weight empty	Nominal capacity	Approx. total weight empty	Nominal capacity
Feet	cwt.	gal.	cwt.	gal.
8 × 4	39	700	67	1500
8 × 8	58	1400	96	3000
12 × 8	77	2100	127	4500
16 × 8	96	2800	153	6000
20 × 8	115	3500	182	7500
24 × 8	134	4200	211	9000
28 × 8	153	4900	240	10500
12 × 12	103	3150	157	6750
16 × 12	124	4200	190	9000
20 × 12	147	5250	224	11250
24 × 12	172	6300	257	13500
28 × 12	195	7350	290	15750
32 × 12	219	8400	324	18000
16 × 16	152	5600	228	12000
20 × 16	181	7000	266	15000
24 × 16	210	8400	304	18000
28 × 16	237	9800	342	21000
32 × 16	266	11200	380	24000
36 × 16	295	12600	418	27000
20 × 20	212	8750	307	18750
24 × 20	246	10500	350	22500
28 × 20	278	12250	391	26250
32 × 20	311	14000	435	30000
36 × 20	344	15750	476	33750
40 × 20	377	17500	518	37500
24 × 24	283	12600	396	27000
28 × 24	321	14700	443	31500
32 × 24	358	16800	491	36000
36 × 24	397	18900	538	40500
28 × 28	363	17100	495	36700
32 × 28	405	19600	546	42000
36 × 28	448	22100	598	47200
32 × 32	453	21500	604	46100

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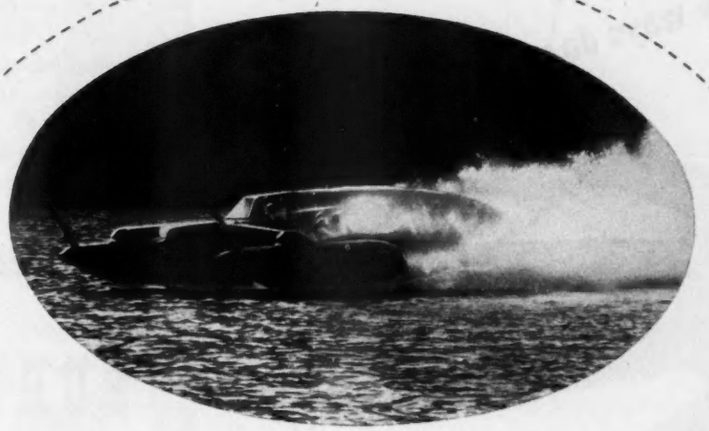

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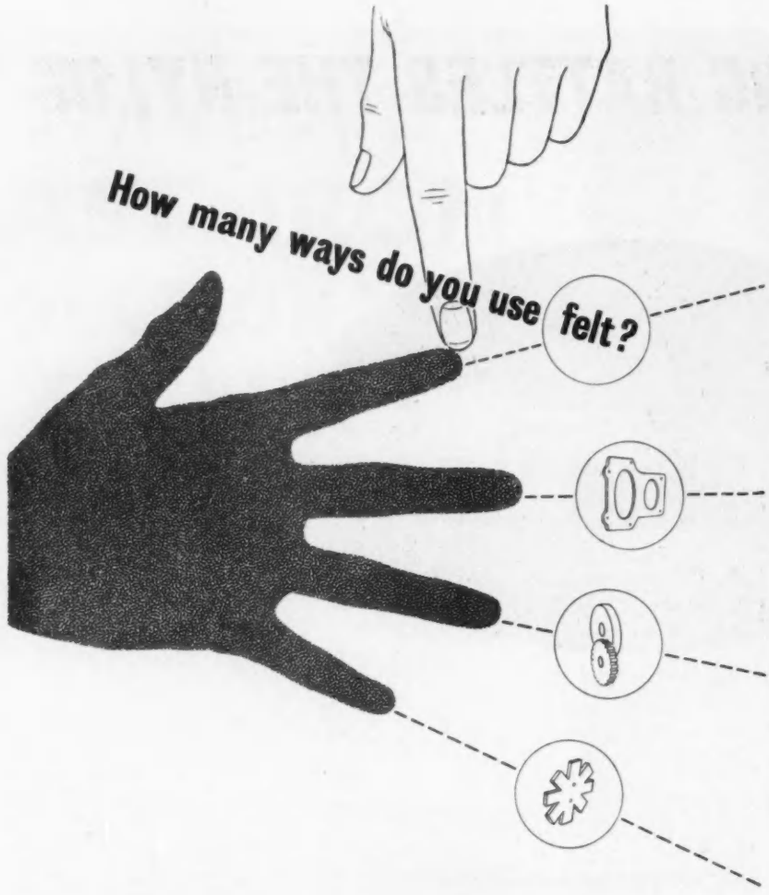

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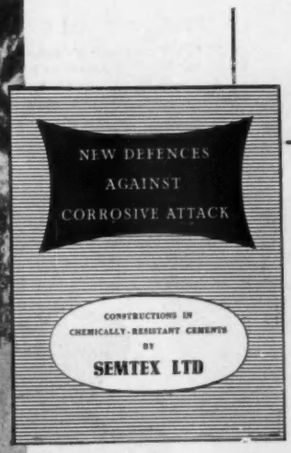

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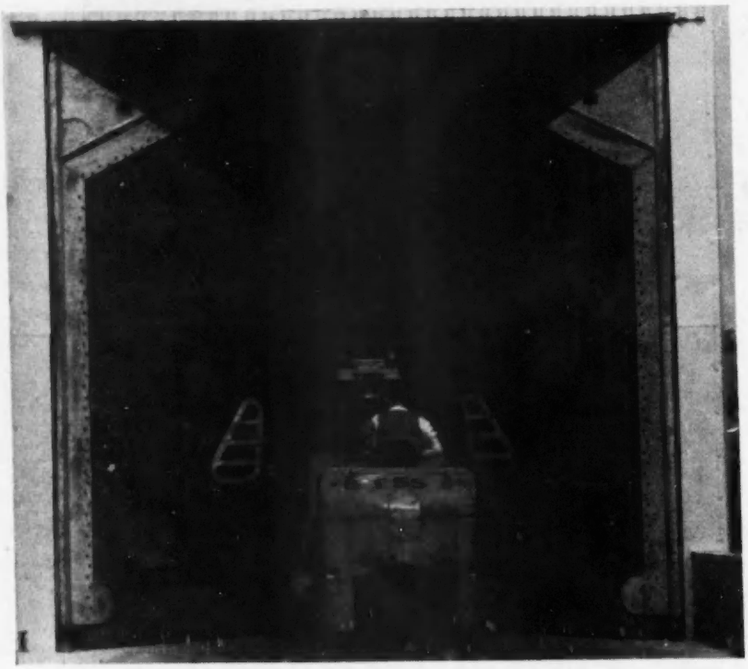

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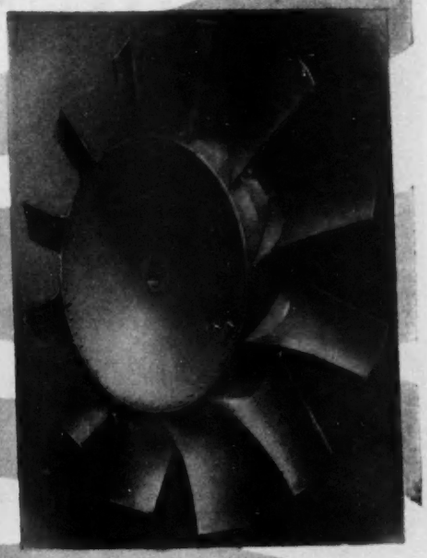

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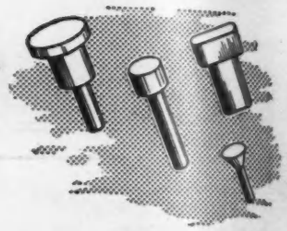

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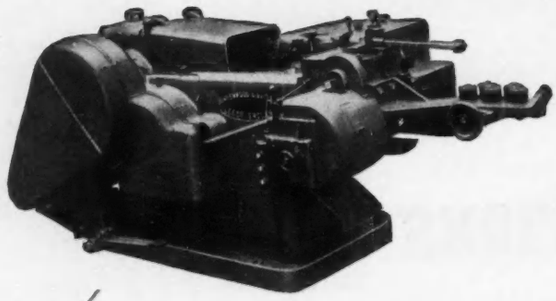

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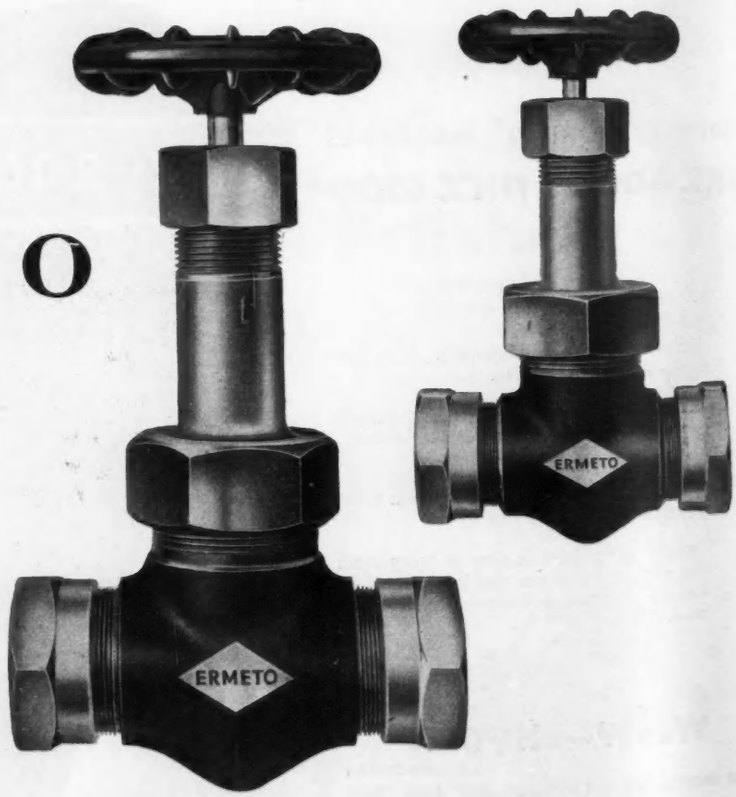

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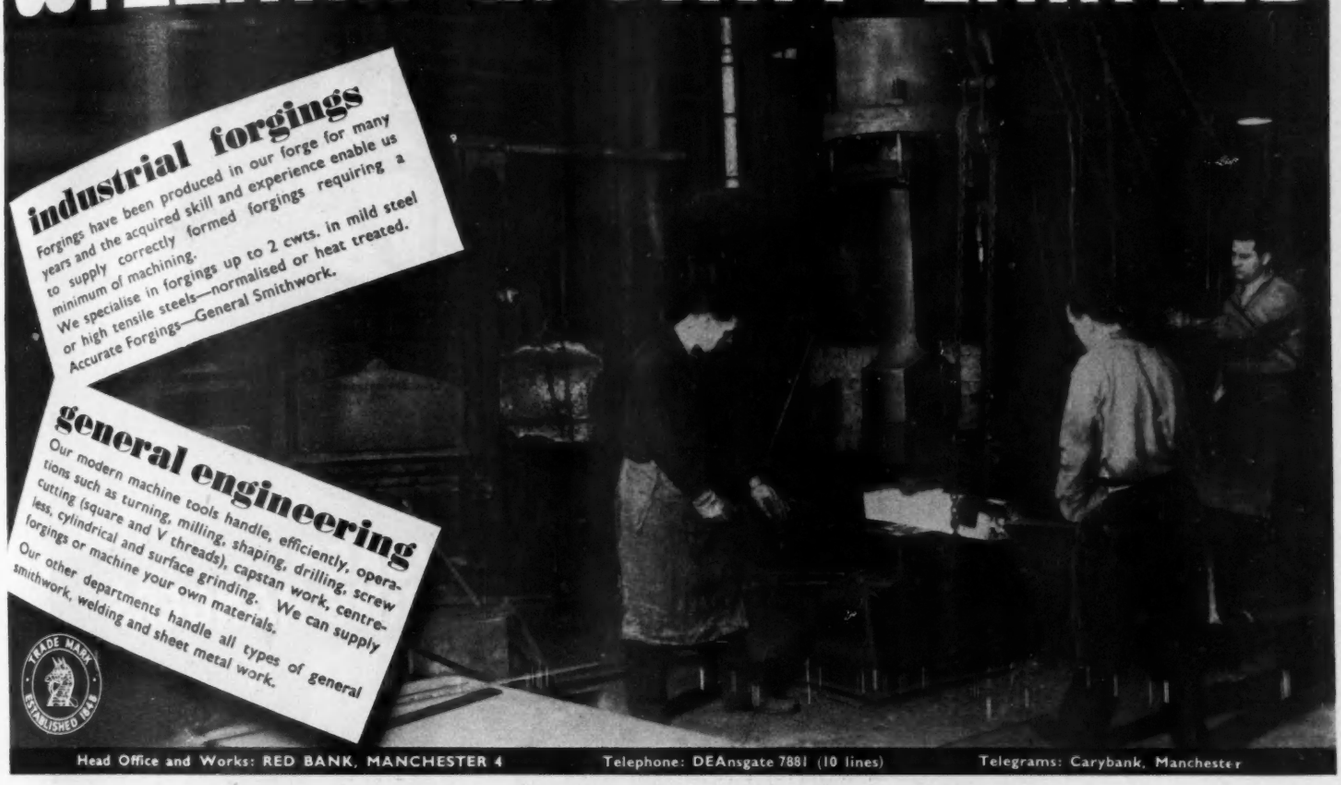

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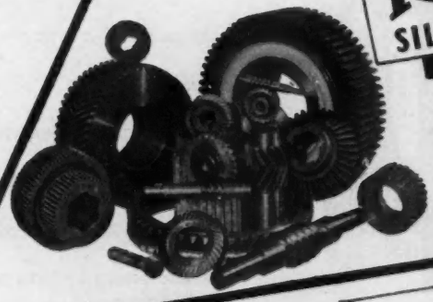

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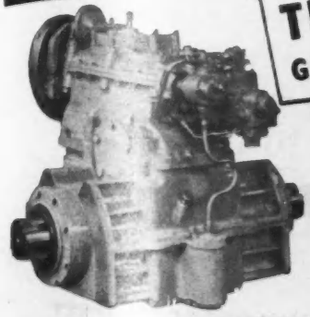

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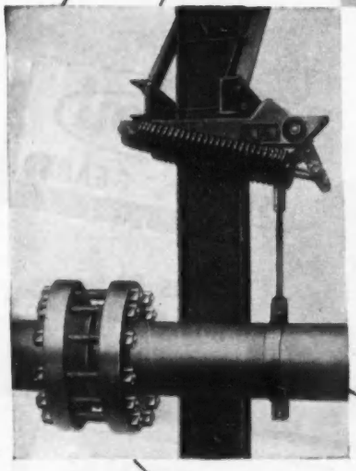

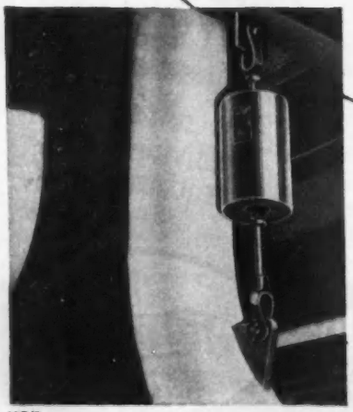

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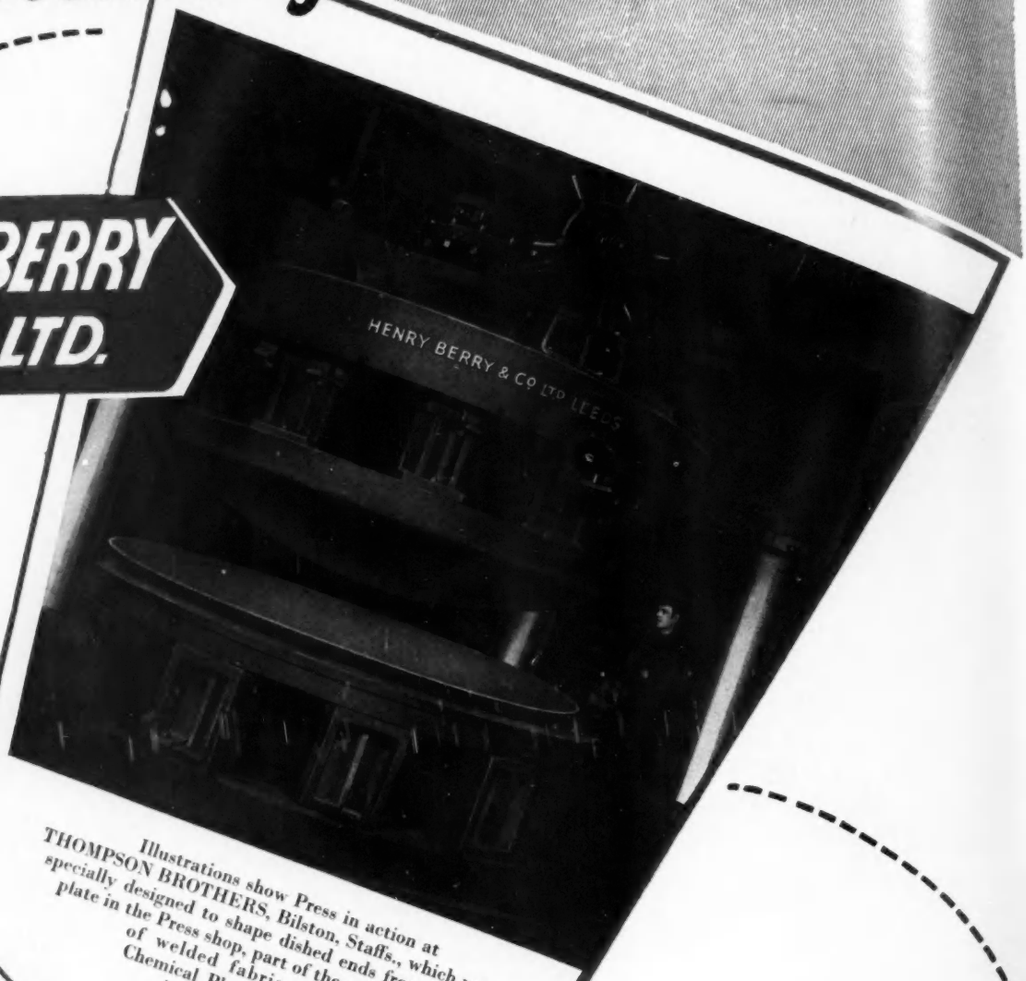

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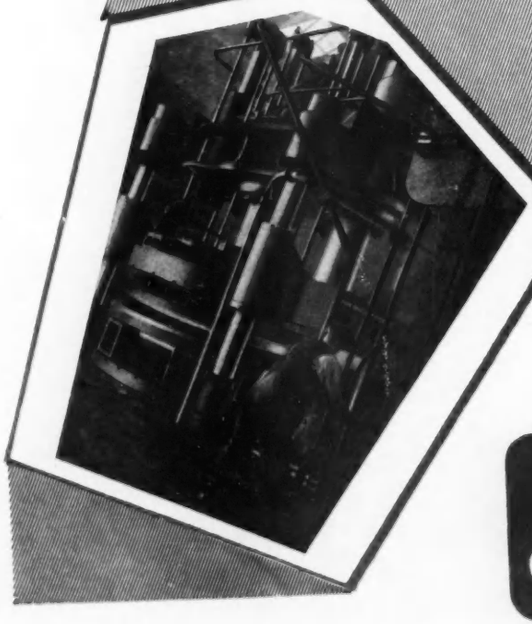

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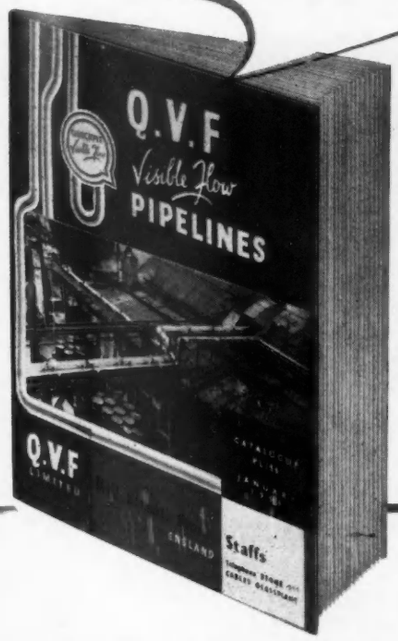

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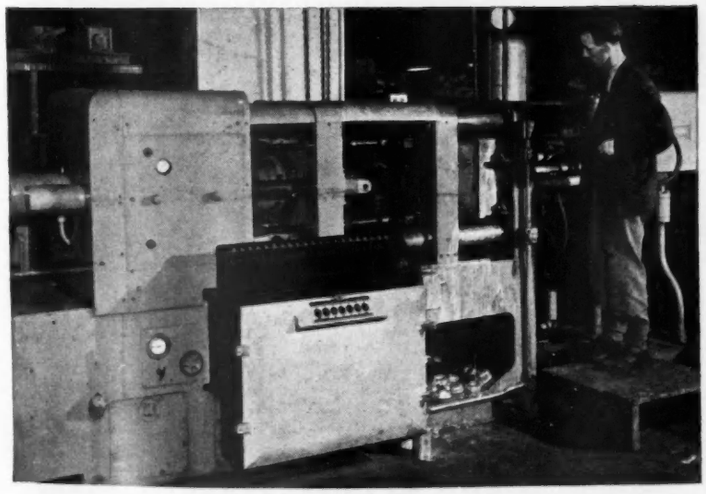

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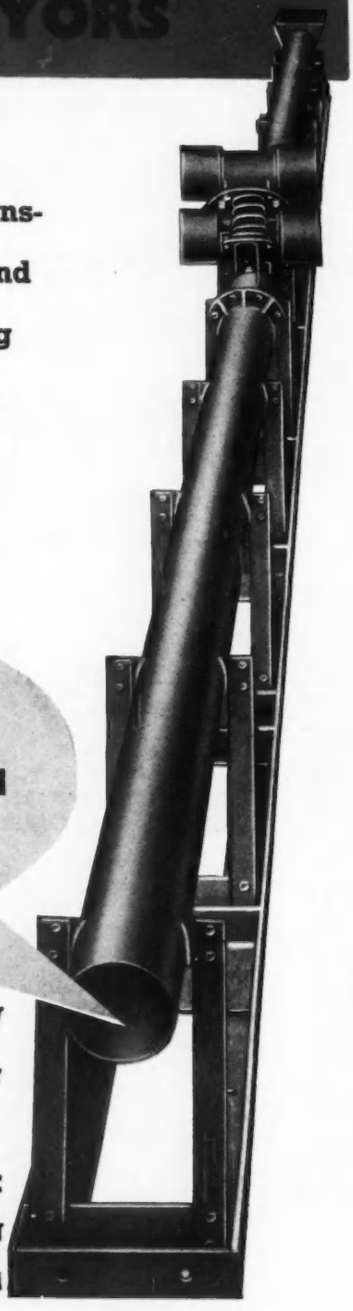

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SHARPER white or blueprints

Strong...
Venus Pencil leads are pressure-proofed* for maximum strength

SMOOTH...
made by a special colloidal process* which removes all impurities

ACCURATE...
exactly graded in 17 different degrees of hardness

*Exclusive Venus Patents

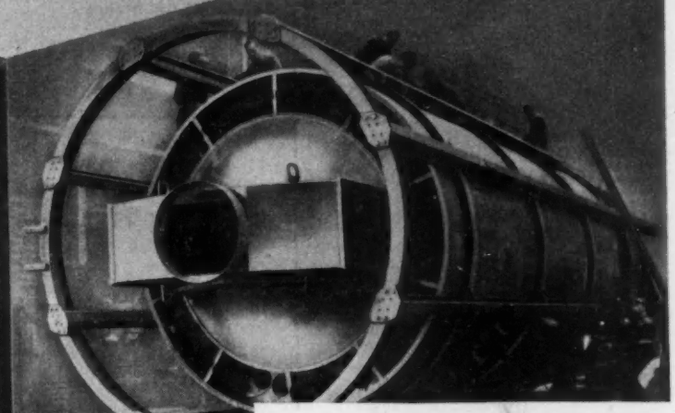
Durable non-crumbling points; strong and smooth in action give lines uniform in weight and tone. Opaque lines for sharp, clear reproduction. No smudges. No "ghosts" from erasure. There's the right degree for your favourite paper. The result: sharper prints — by any process!

VENUS DRAWING PENCILS

Use also Venus Soft Pencil Eraser

VENUS PENCIL CO. LIMITED
LOWER CLAPTON ROAD, LONDO , E.5

VERSATILITY IN WELDED STEEL fabrication . . . .

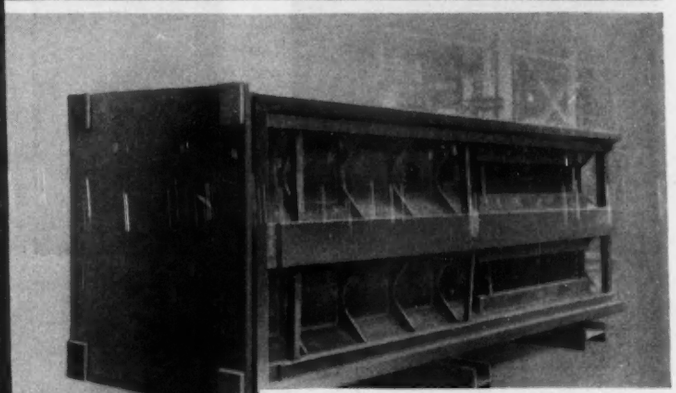


23-ton Main Body, Oil Distillation Unit

We have built up very substantial and comprehensive productive and design resources at Stourbridge.

Among a wide variety of fabrications currently in production for many industries, we are making ships' davits, gearcases and bedplates, machine tool bodies and frames, transformer and condenser shells, main components for earth-moving equipment, and rolled and welded pipework.

If you have a fabrication problem in these or other fields, our long experience and technical knowledge well qualify us to advise and assist you; and we cordially invite your enquiries at an early stage.



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15-ton Electrical Transformer Tank

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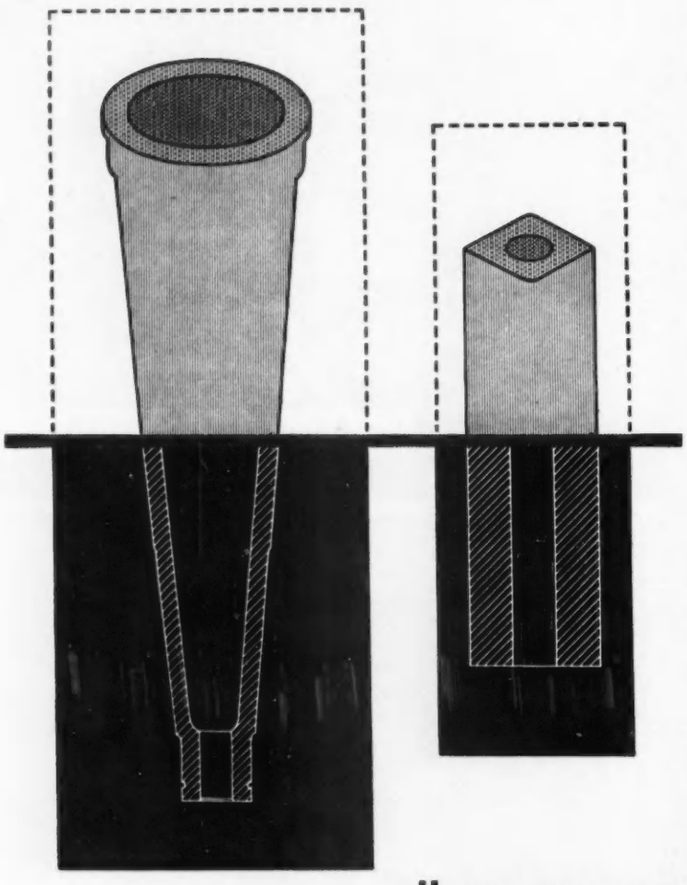
HOLLOW BORED SHAFTS



all on our own

We are the only people to commercialise *deep hole drilling*. By this method we produce hollow bored shafts, the chief advantages of which are as follows :—

PRICES ARE KEEN particularly where small quantities or special sizes are required, or where the bore diameter is less than half the outside diameter.

SPECIAL PROBLEMS can be dealt with by the hollow boring method that cannot be dealt with practicably by any other process. We can for instance drill different diameter bores within one shaft, profiled if necessary to any shape required. If you want quick delivery of hollow bored shafts—whether in stock sizes and shapes or to your own specifications—it's worth getting to know more about Keeton's. We bore any diameter hole from ¼" to 6" in lengths up to 4' in the smaller bores and up to 18' in the larger bores. Send for free leaflet.

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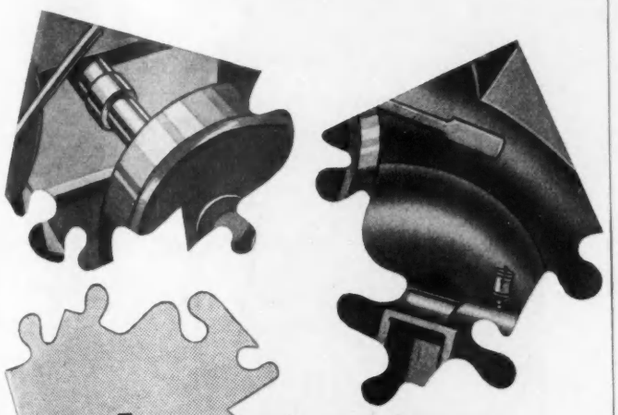

the missing part

The manufacturer with a production problem has a simple recourse . . . *contact Carron.* Innumerable firms who have not the resources or equipment to produce certain specific components for their products find that Carron can usually supply the missing part. For this huge company with its 130 acres of foundries, forging shops, machine shops, enamelling plant and sheet metal fabrication offers a complete service. Why not get in touch with Carron now? You may well save valuable time . . . and money.

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READY TO SERVE YOU

CARRON COMPANY
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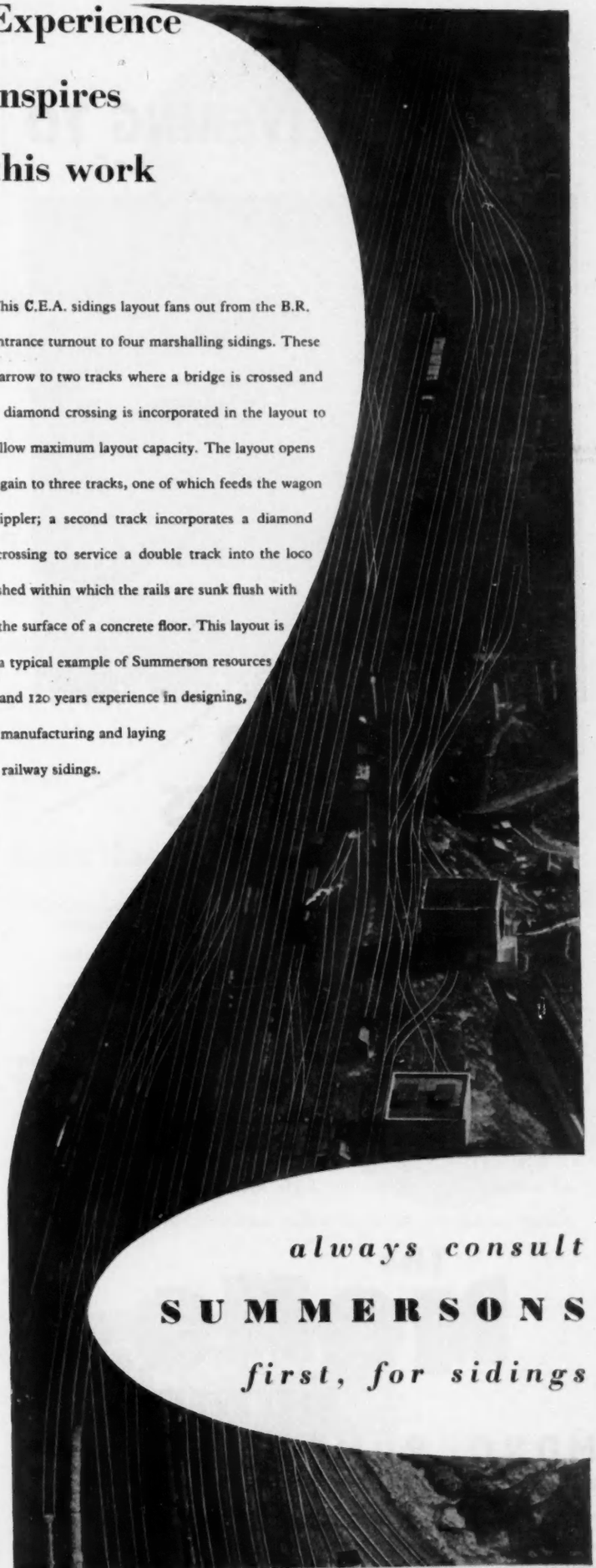
E2B

Experience inspires this work

This C.E.A. sidings layout fans out from the B.R. entrance turnout to four marshalling sidings. These narrow to two tracks where a bridge is crossed and a diamond crossing is incorporated in the layout to allow maximum layout capacity. The layout opens again to three tracks, one of which feeds the wagon tippler; a second track incorporates a diamond crossing to service a double track into the loco shed within which the rails are sunk flush with the surface of a concrete floor. This layout is a typical example of Summerson resources and 120 years experience in designing, manufacturing and laying railway sidings.



always consult

SUMMERSONS

first, for sidings

THOMAS SUMMERSON & SONS LTD., MOWDEN HALL, DARLINGTON, CO. DURHAM.
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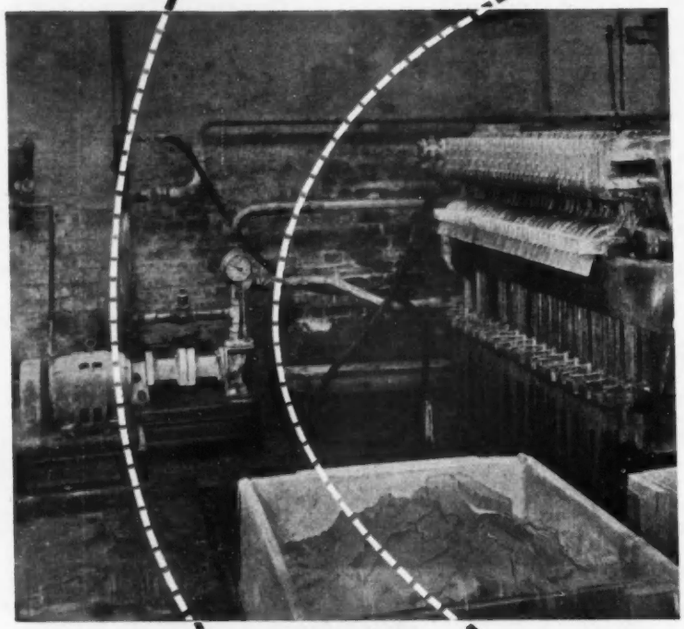

FILTER PRESSES

To obtain a firm cake with low moisture content a steady even pressure is required from a pump delivering fluid or slurry to a filter press. A pulsating flow will destroy the structure of the cake, resulting in an uneconomic operation. The inherent low velocity of the Mono Pump, with its steady performance against varying pressures, enables it to be ideally applied to filter press duties. Further, it has the additional advantages of self-priming, high suction power and ability to handle slurries or solids suspended in liquid.

The MONO pump

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Cables: Monopumps, London · Code: A.B.C. 7th Edition
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***Your** valve problems are **our** business!*

"The Lancaster" REGD TRADE MARK

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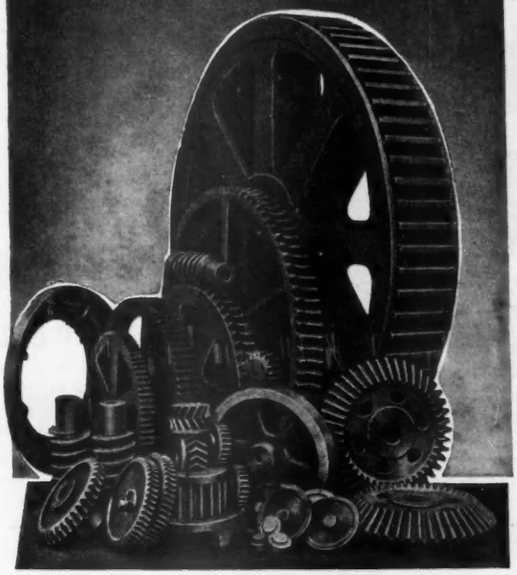

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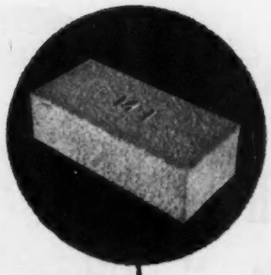
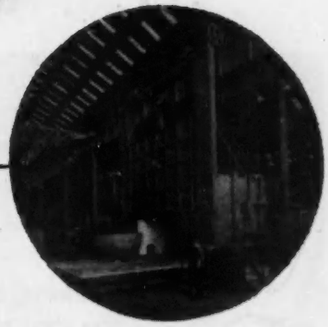


Low heat storage furnace linings



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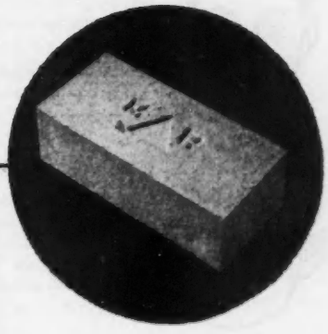

Things about which it can pay you handsomely to consult . . .

MORGAN refractories

HIGH DUTY AND INSULATING BRICKS — CASTABLES AND MOULDABLES — TUBES AND HOLLOW WARE

For further information please write to:—
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"Now, tell me this..."

"What is Ferobestos?"

Ferobestos plastics are non-metallic asbestos based materials impregnated with resins and moulded into a hard insoluble, infusible substance. It is an engineering material in its own right.

"What advantages has Ferobestos over other materials?"

Ferobestos has outstanding basic advantages :—

- High strength in proportion to weight
- High temperature resistance
- Low moisture absorption
- Good chemical resistance
- Good electrical resistance
- High wear resistance
- High dimensional stability

"How is Ferobestos supplied?"

Ferobestos plastics are usually supplied in sheets, rods and tubes, but they can also be moulded to your requirements where contour permits and where quantity justifies the cost of mould tools. All forms of machining are carried out for you where necessary.

"How are other engineers using Ferobestos?"

Engineers in all branches of industry have solved constructional problems with Ferobestos Plastics.

Here are just a few of its applications :—

Bushes · Coupling Discs · Guides · Mounting Pads
Gears · Rollers · Piston Rings · Wearing Slippers
Bearings · Compressor Blades · Thrust Washers

"What sort of service is behind Ferobestos?"

J. W. Roberts Limited, who specialise in engineering and structural applications of asbestos, have set up a new department, entirely devoted to the development of Ferobestos Technical Plastics. This ensures a prompt, efficient service to engineers and designers.

"get me J. W. Roberts Limited Ferobestos Department"

Branch Sales Offices: London, Birmingham, Glasgow, Leeds.

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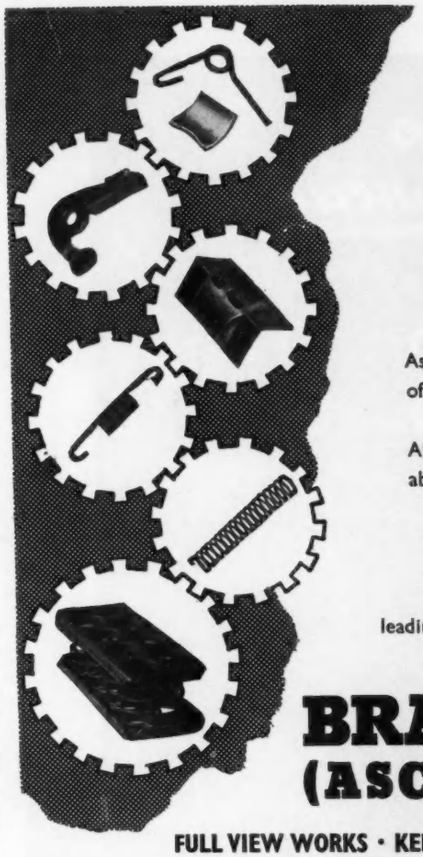

Every part an integral one

As specialists in the manufacture of all types of springs, pressings, clips, and "Metpaks" Shock Absorbers, Brayhead put quality above all, and at the right price. No matter how small the components may be, each one is designed and made to meet the exacting standards of the leading industrialists who use them.

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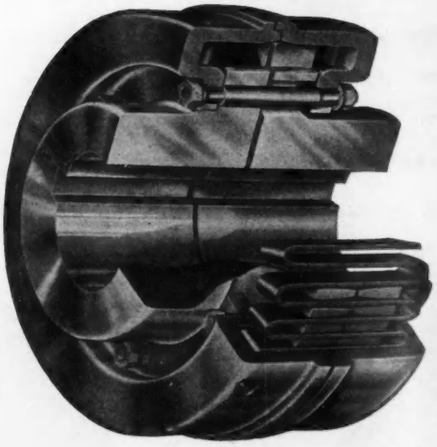

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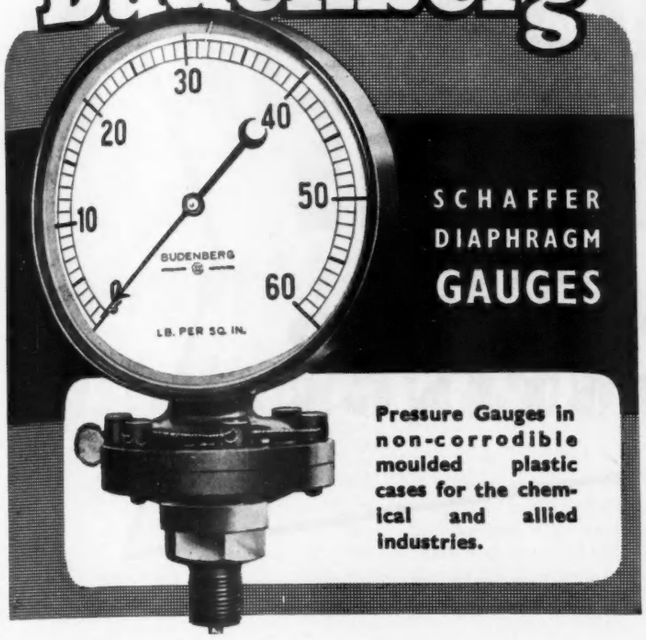

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Pressure Gauges in non-corrodible moulded plastic cases for the chemical and allied industries.

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Here is the perfect jointing for high pressure smooth surface or screw unions!

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OSOTITE—the modern scientific sealing which has been proved by rigorous tests to be the perfect jointing for smooth surface and screw unions. OSOTITE is a simply applied liquid compound, impervious to heat, petrol, oil, grease, water and steam, which ensures in a few minutes a HIGH PRESSURE GAS, AIR or WATER-TIGHT JOINT.

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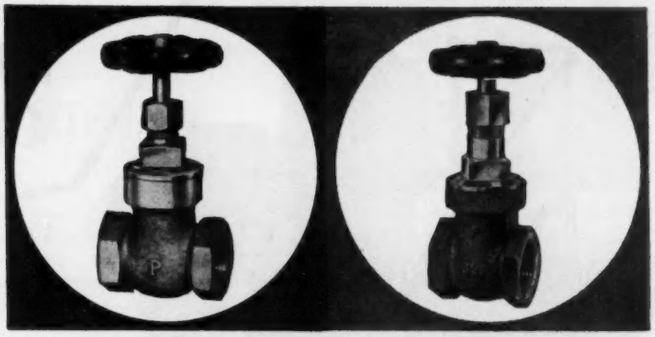
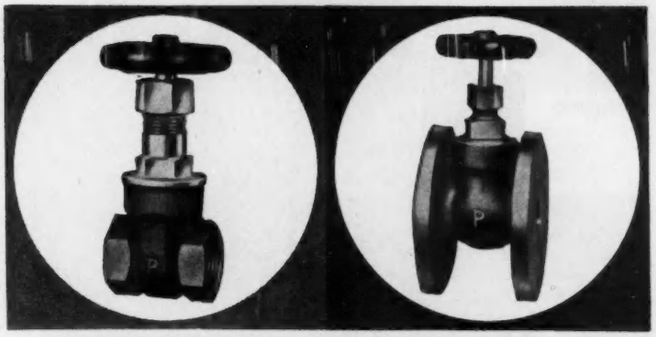
HIGH PRECISION : LOW PRICE



1070 (Gunmetal)
Up to 200 lbs. steam. Round body, non-rising spindle, solid wedge. Sizes ¼"—4".

1070/125 (Gunmetal)
Up to 125 lbs. steam. Hydraulic and oil working pressures up to 200 lbs. P.S.I. Non-shock. Sizes ¼"—4".



1070HP (Forged Brass)
Up to 300 lbs. water. Double action, quick lift, solid wedge. Sizes ¼"—1½".

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Up to 150 lbs. steam. Flanged ends to B.S.T.E. Round body, non-rising spindle, solid wedge. ¼"—3". 4" size with bolted cover.

1077 (Gunmetal)
Handy lever—full operation by a quarter turn. Sizes ¼"—2".

Peglers can supply a very wide range of types and sizes of gunmetal valves in general commercial use at a price made possible only by continuous large scale production.

The Fullway Gate type group, for example, includes valves for most purposes—all fully tested.

★ *Worth noting—"Peglers for all gunmetal valves and cocks on air, water, oil and steam services".*

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For SPECIALISED CASTINGS

Illustrated:—a motor driven vacuum drier, 7′ 9¾″ dia. × 2′ 6″ deep ; steam heated by coils cast in the body and base.

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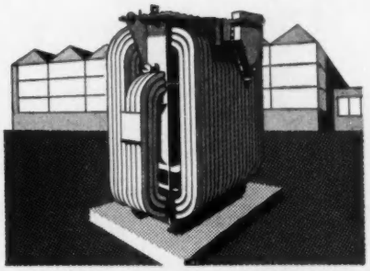
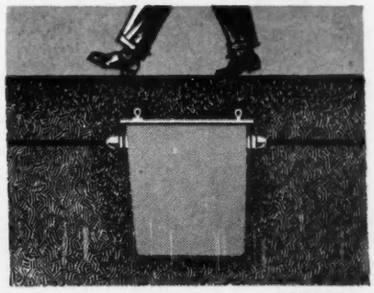
POLE-MOUNTING TYPE

Ferranti Top Quality Distribution Transformers

Ferranti Ltd. offer a complete range of Distribution Transformers up to 1000 kVA including types to B.E. Specification T.I (1954), for delivery from stock.
A quick delivery service is available for transformers built to customers' special requirements.



SUB-STATION TYPE



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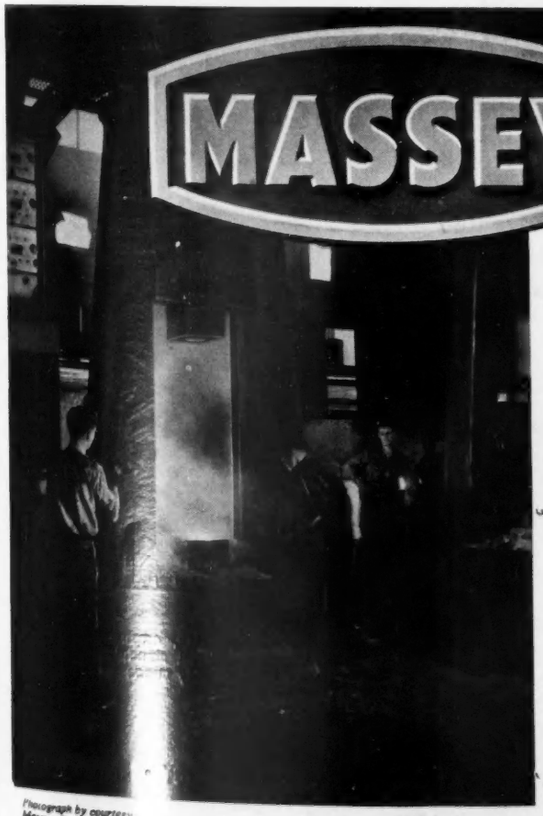

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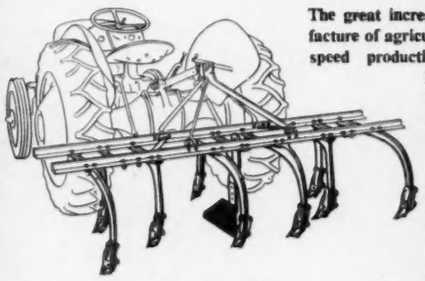
FOR AGRICULTURAL MACHINERY



The great increase in the mechanisation of manufacture of agricultural machinery has demanded high speed production of forging components, and MASSEY Forging and Drop Forging Plant is used extensively in this field of engineering industry. The photograph shows a Massey Friction Drop Hammer installed at Garringtons Ltd., Darlaston, and is one of many used for forging parts for the famous Ferguson Tractor.

Full details of Massey Forging and Drop Forging Plant will be forwarded upon request.

Massey designs include:
Steam and Compressed Air Hammers, Pneumatic Power Hammers, Spring Power Hammers, Friction Drop Hammers, Double-acting Steam and Compressed Air Drop Hammers, Forging Presses, Trimming Presses, Tyre Fixing Rolls.

Photograph by courtesy of Messrs. Garringtons Ltd., Darlaston.

Visit us at Stand No. 33 at the International Machine Tool Exhibition, 1956, June 22—July 6, Olympia, London

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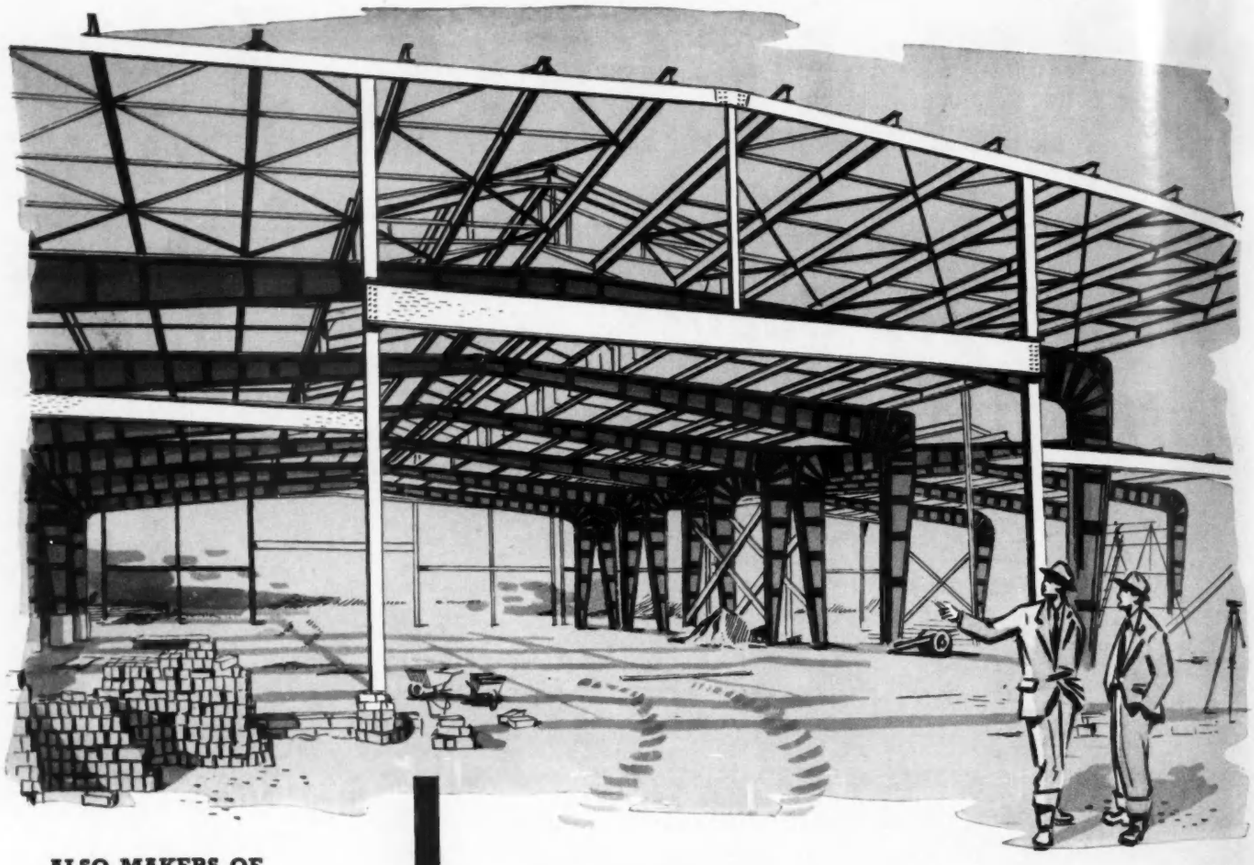
MAKERS OF THE WORLD'S GREATEST RANGE OF FORGING PLANT



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Overhead Electric Travelling Cranes

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Sheet Metal Machinery

Wrought iron

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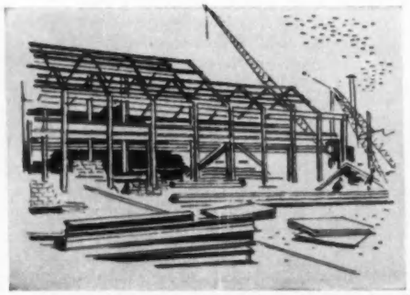
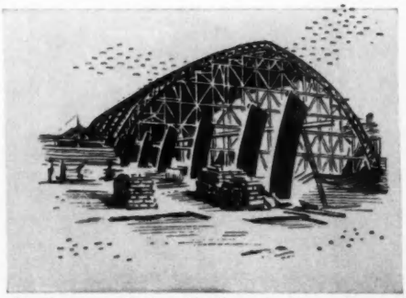
BUTTERLEY BUILT

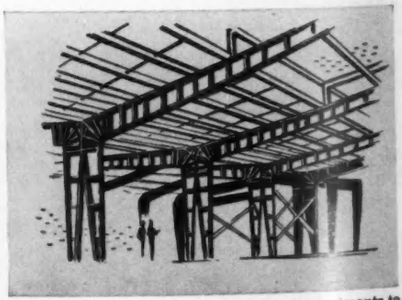
Besides building many examples of constructional steelwork both in this country and abroad we at Butterley have also built up quite a reputation for skill and knowledge in the constructional steelwork field. Our service to industry covers every stage from design, through to fabrication and erection on site. We widely employ welded methods and our shops are well-equipped to undertake the largest and heaviest work of this nature.



A typical example of Butterley Constructional Steelwork for an engineering works.



St. Pancras Station Roof made throughout of Butterley wrought iron and erected by Butterley in 1867.



In recent years, experiments to perfect welded structures have been highly successful.

FOUNDED 1790

Butterley

CONSTRUCTIONAL STEELWORK

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LONDON OFFICE: 9 UPPER BELGRAVE ST., S.W.1.

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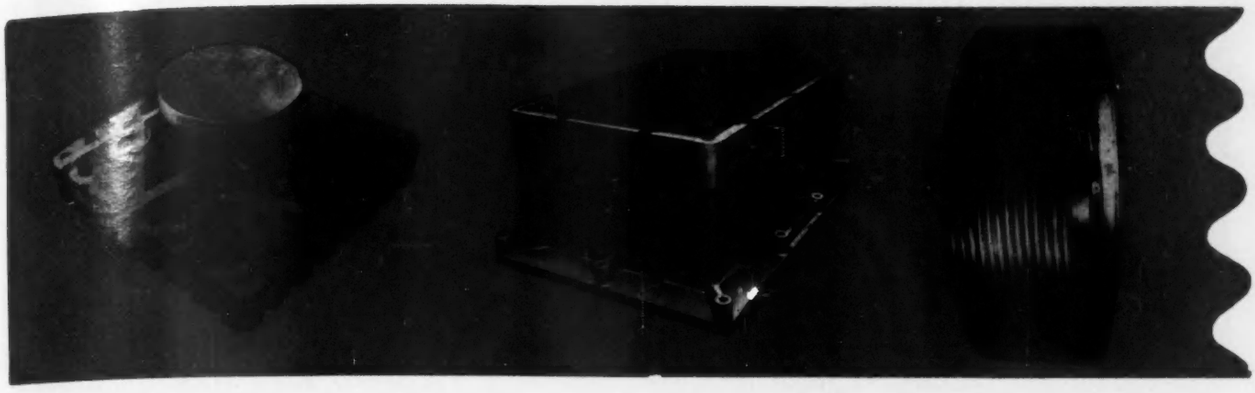
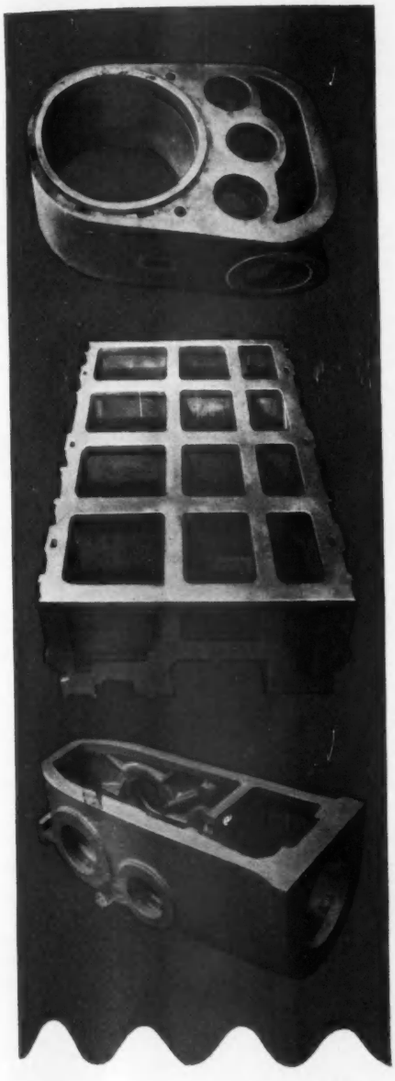
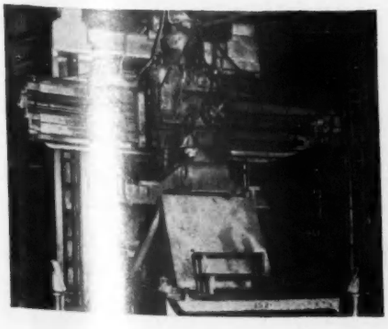




SPORTING & FOUNDRY LIFE

These fragments torn from the frieze of our boardroom show castings which we are in the habit of making after we have taken the precaution of protecting our shooting boots with asbestos spats. Not that we let a lot of hot valuable metal fly about, nor much else in this district for that matter. After a week-end when partridges develop legs like a billiard table through having to walk, we come into work and straighten out our hammerless ejectors under our ejectorless hammers. Then we cast one and a half thousand tons of metal, most of it West Coast Hematite iron, but a customer has only to raise his trigger finger and say "I want my casting in grey iron" or "Special iron to this analysis, please" and all the machinery to oblige him is set in motion. What could be fairer ? And what could be better than a Distington casting ?

DISTINGTON ENGINEERING COMPANY LIMITED
WORKINGTON CUMBERLAND ENGLAND
CASTINGS IN WEST COAST HEMATITE, GREY, AND SPECIAL IRONS



We machine castings of course. Our modern etc. etc. machine shops are well equipped with the most up-to-date etc. etc. machine tools—you know the formula. We see (left) our Irish Setter, Sand Slinger Champion II watching another setter setting up a job on one of our plano-milling machines.

CA9

International photo contest

THIS IS THE TYPEOF PHOTOGRAPH WE WANT–
showing the Arpic Compressor at work in any interesting surroundings.

To obtain photographs of ARPIC AIR COMPRESSORS at work in interesting surroundings, Arpic Engineering invite entries to the 'ARPIC' International Photo-Contest.

Built for heavy duty and reliability in all climates, whether hot or cold, dry or humid, ARPIC COMPRESSORS are giving sturdy service in more than 40 different countries. Arpic Engineering make a range of Portable and Stationary Air Compressors—petrol or diesel driven—from 75 to 600 c.f.m.

'ARPIC' INTERNATIONAL PHOTO-CONTEST

1. Everyone attracted by this contest is cordially invited to participate. The type of pictures required are those showing **Arpic Air Compressors in interesting surroundings.** The top illustration showing an **Arpic Compressor** at work in front of the Parthenon in Athens, is an ideal example of the type of picture required.
2. We will accept up to 4 black and white pictures, and 4 colour transparencies per entry.
Black and white photographs on white glossy paper suitable for reproduction. Minimum size 18 x 24 cm. (8 in. x 10 in.).
Colour transparencies of minimum size 24 x 36 mm. (1 in. x 1½ in.). However, preference will be given to the larger 10 x 12 cm. (4 in. x 5 in.), Ektachrome or similar. The acceptance of smaller types will be influenced by the possibilities of photo-mechanical reproduction.
3. On the back of the picture, or enclosed with each transparency, give the following details:—Locality, date when the picture was taken, working conditions, and any other interesting detail, together with the name and address of the entrant.
4. The closing date of the Contest is June 30th, 1956.
5. All pictures should be sent to **Arpic Engineering S.A.** (Dept. EN), Wilrijk, Antwerp, Belgium, marked '**Arpic International Photo-Contest.**'
6. The copyright of all prize winning pictures will become the property of **Arpic Engineering,** and all entries should carry on the back the entrants' agreement to this effect.
7. Pictures not selected will be returned to the owners.
8. An international panel of judges will select the pictures, and the decision of this panel is final.
9. Prize winners will be notified by mail and the results of the competition together with names of the judging panel will be published in the trade press.
10. After selection of the prize winning entries, any remaining pictures which are of interest and value will be purchased at the following rates:—
Colour pictures U.S. Dollars 15 piece.
Black and white pictures U.S. Dollars 10 piece.
11. Members of the Arpic organisation are not allowed to compete.

PRIZES

COLOUR	U.S. dollars	BLACK & WHITE	U.S. dollars
1st Prize	600	1st Prize	500
2nd ,,	400	2nd ,,	300
3rd ,,	200	3rd ,,	150
4th ,,	150	4th ,,	100
5th ,,	75	5th ,,	50
Five next best	30	Five next best	25

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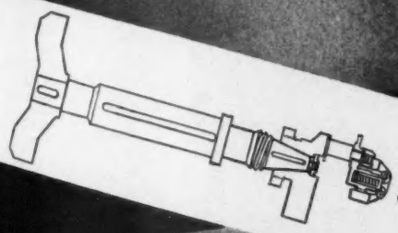
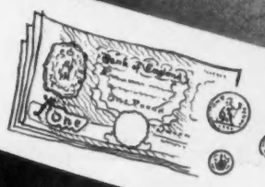


alignment



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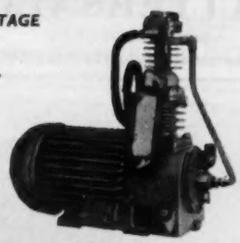

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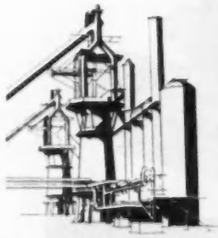

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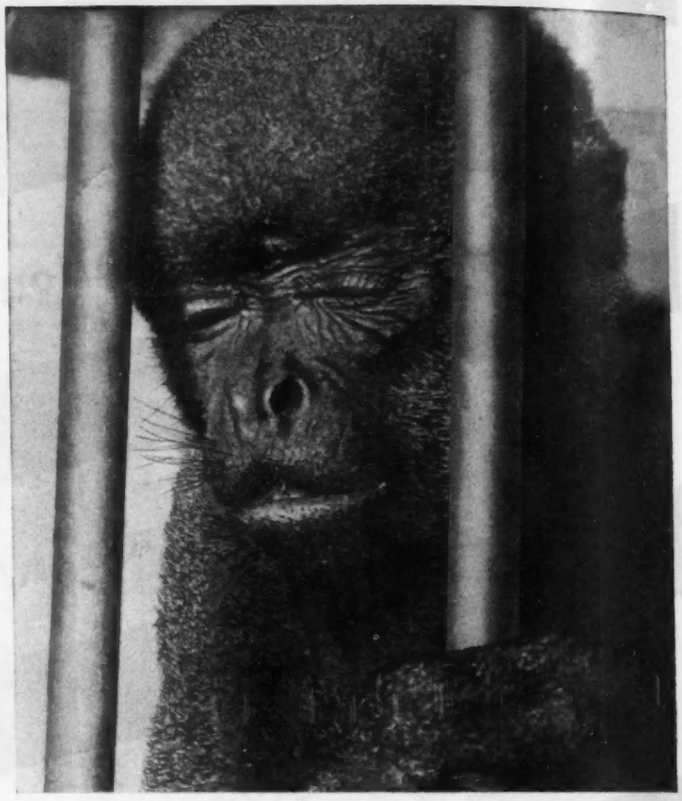

Unlike this obvious source of menace, many modern dangers are unseen. Hundreds of lives may hang on the ability of cable chains, couplings, cage and lifting gear and similar equipment to withstand incessant strain. *That is why Wrought Iron should always be specified for such equipment wherever human safety is at stake.*

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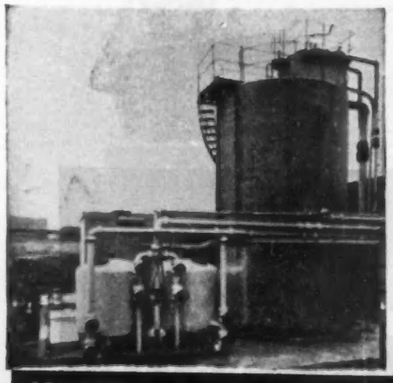

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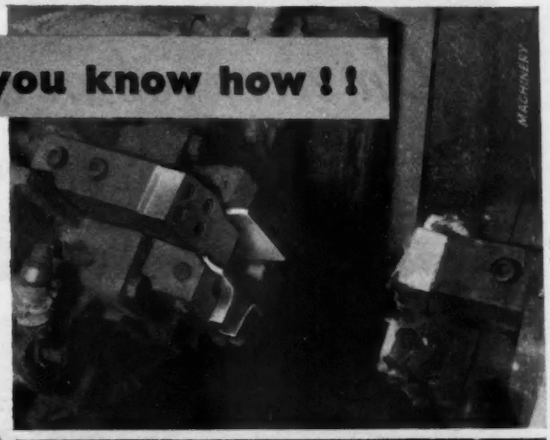

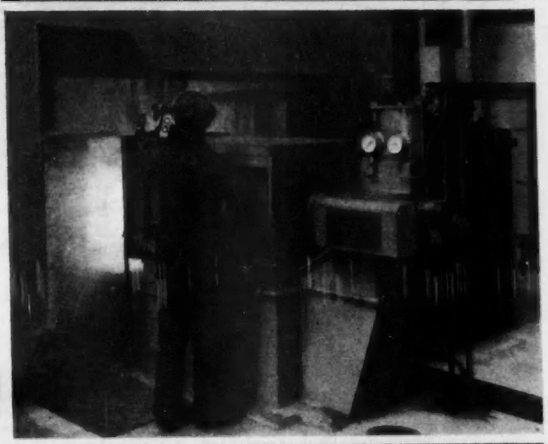

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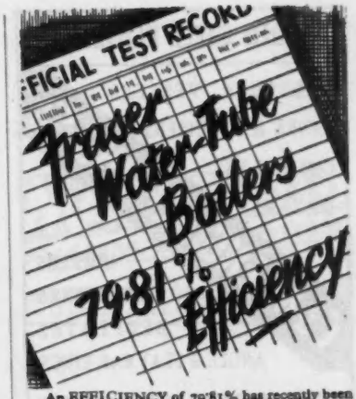

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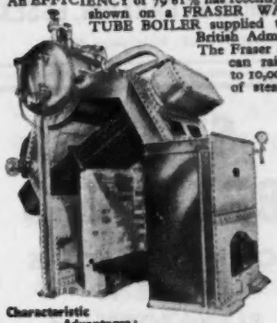

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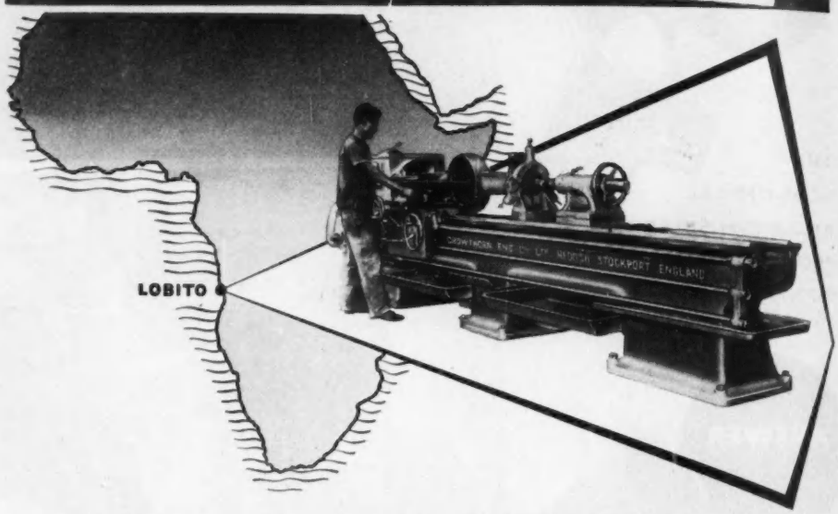

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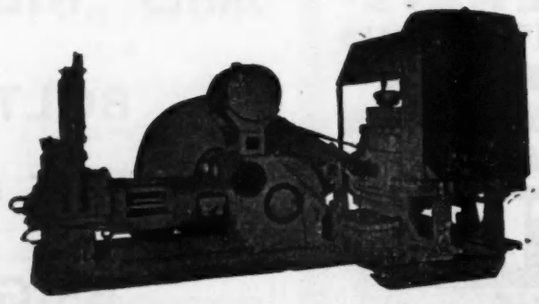

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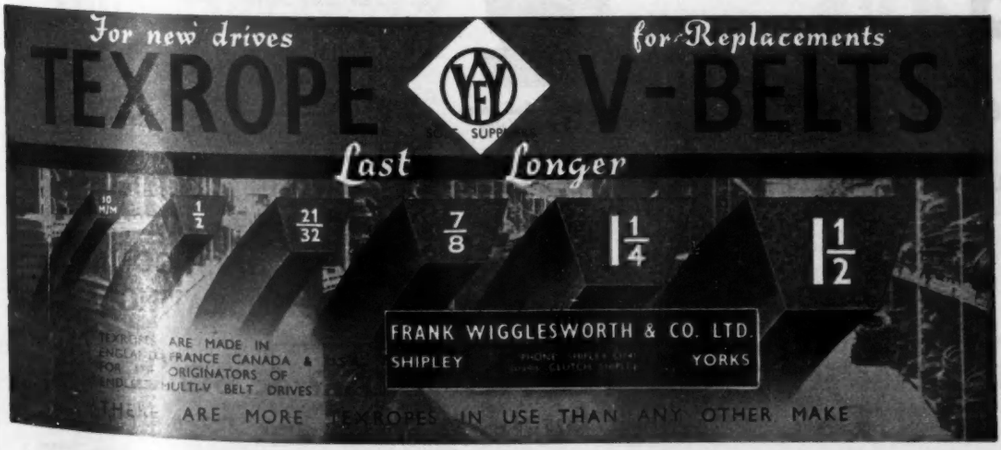

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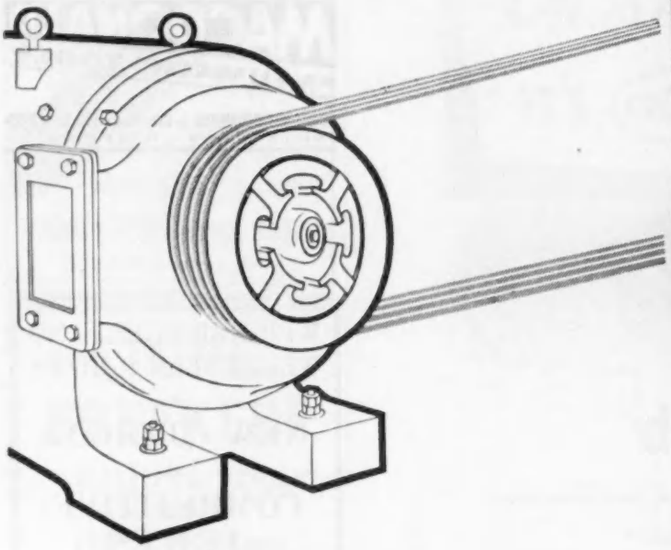

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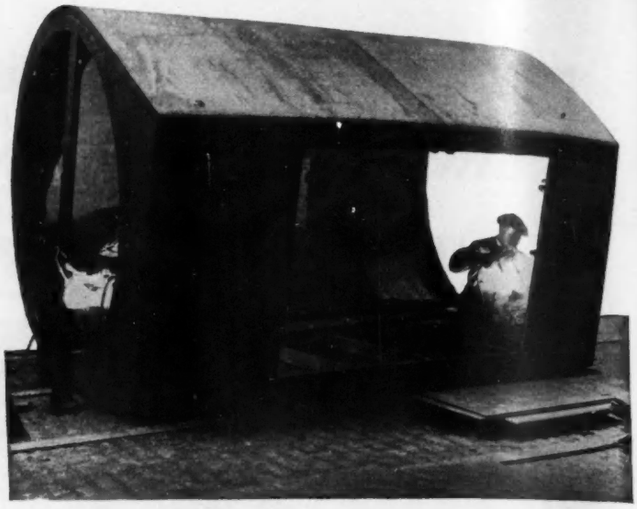

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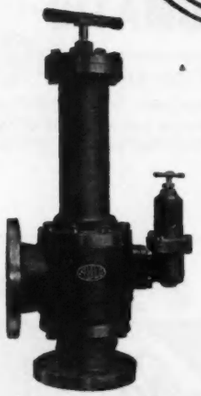

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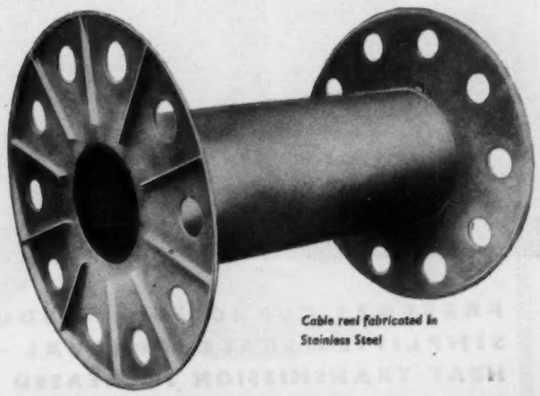

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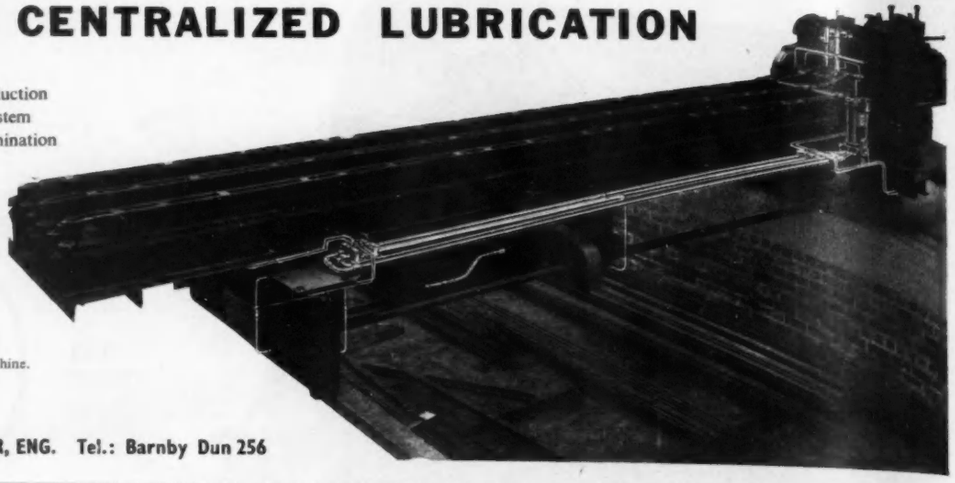

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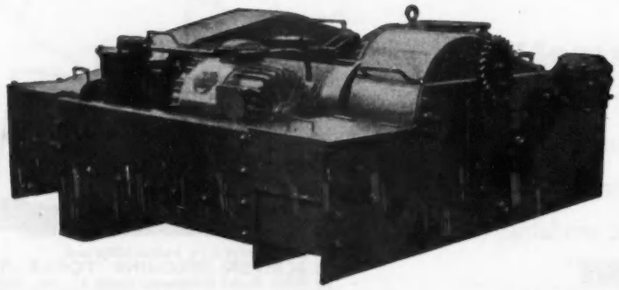

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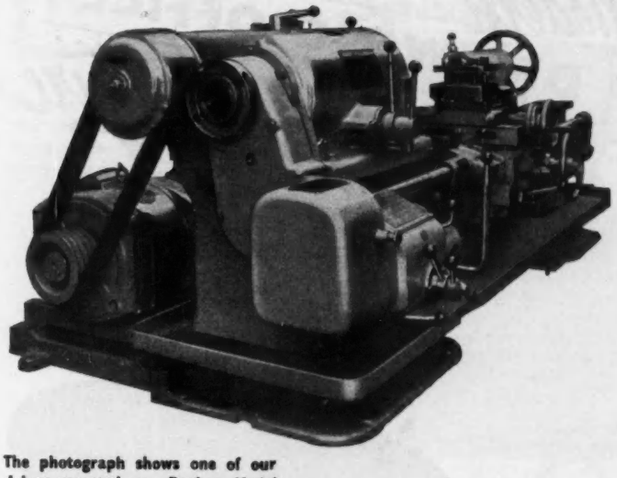

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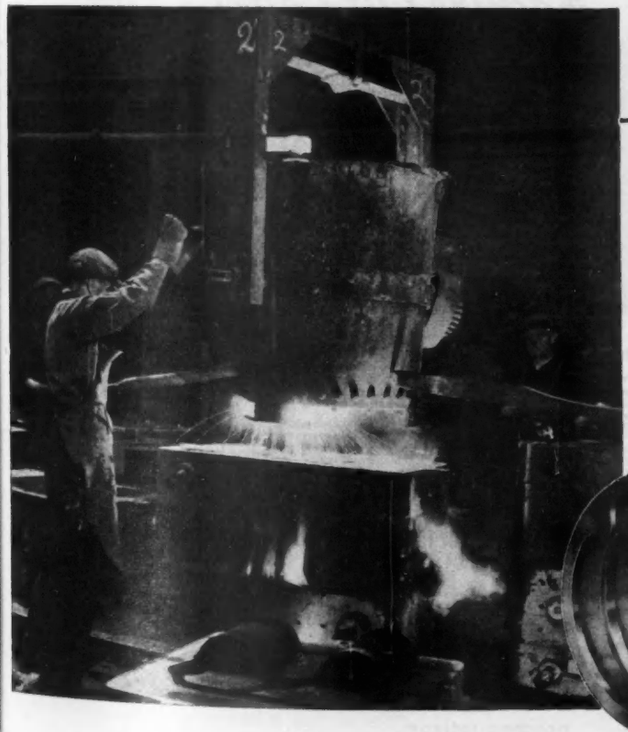

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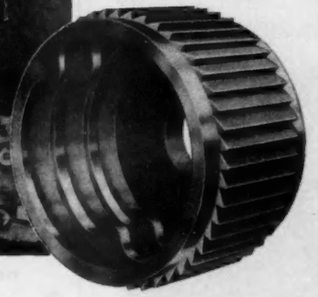

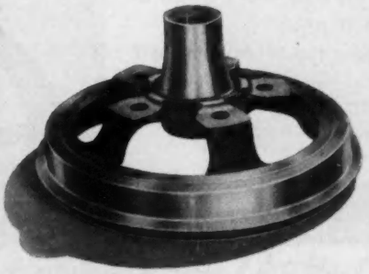

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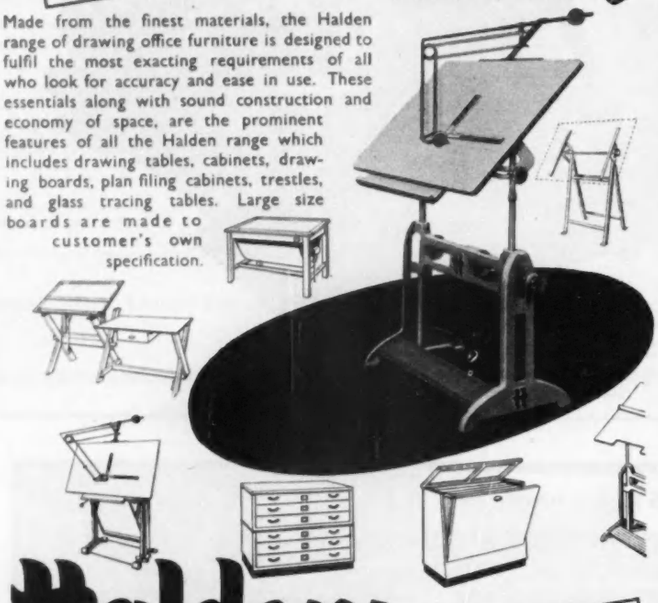

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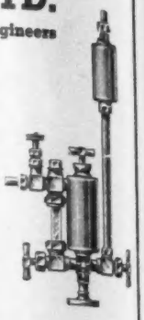

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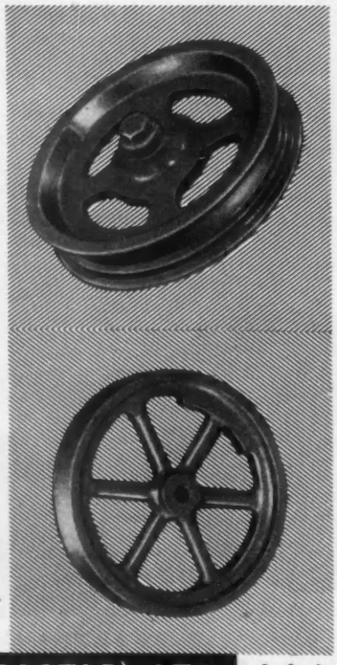

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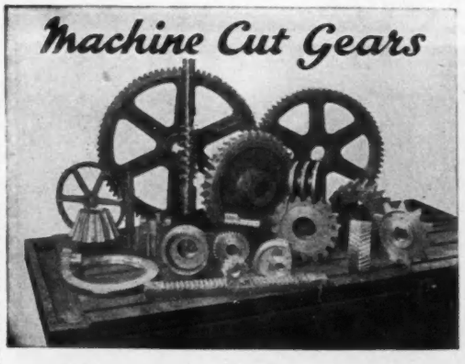

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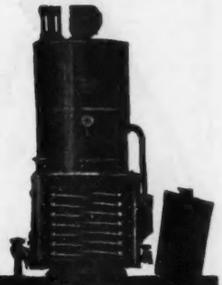

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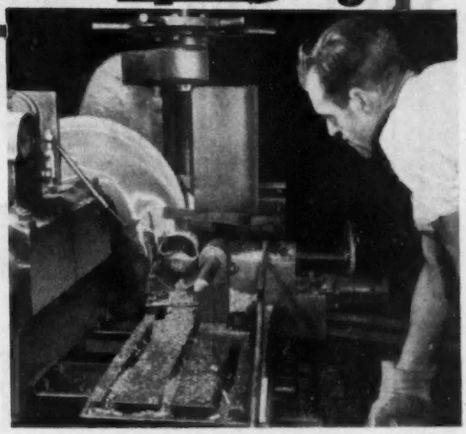

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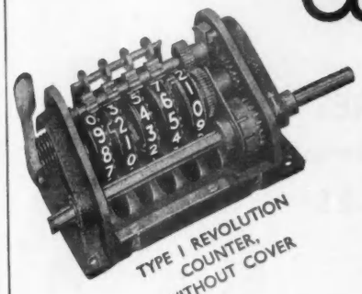

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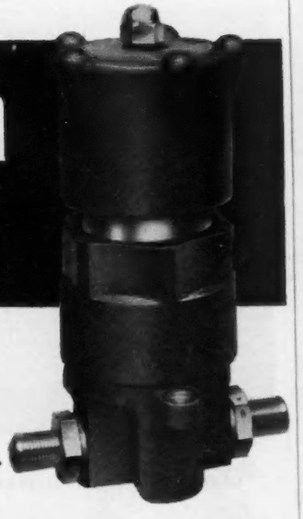

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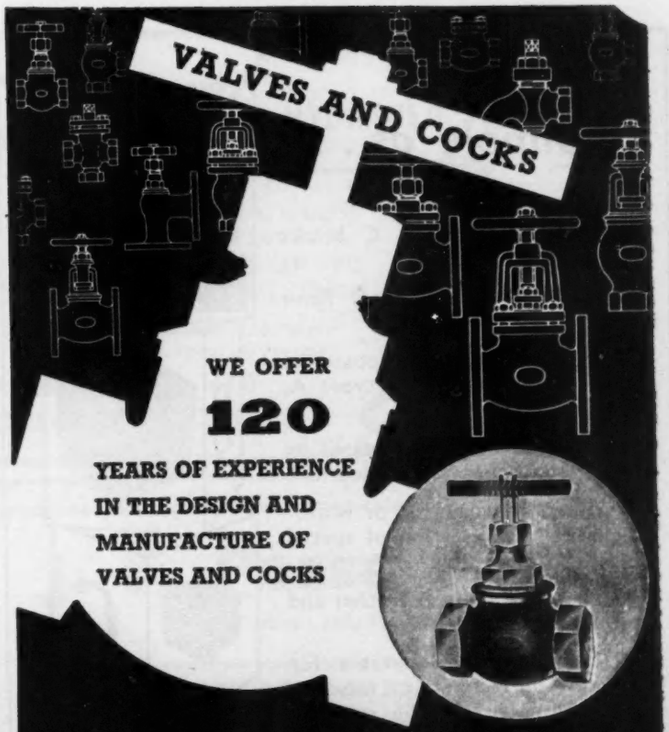

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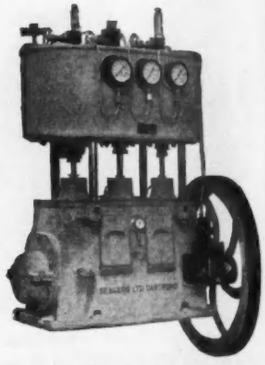

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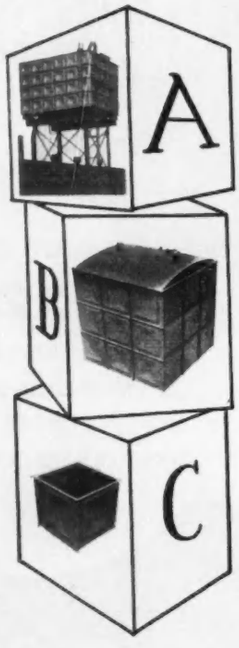

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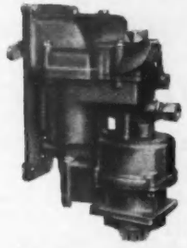

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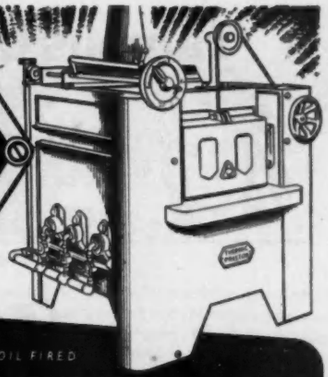

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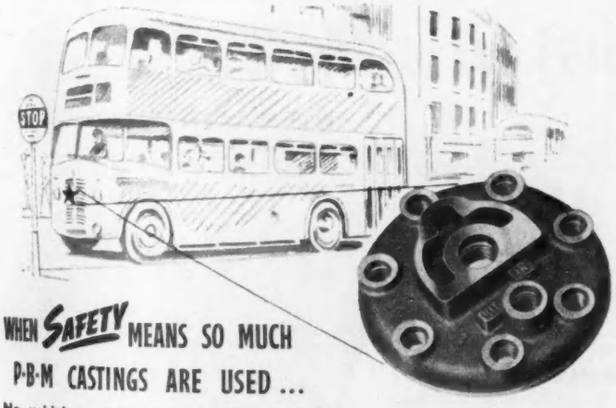

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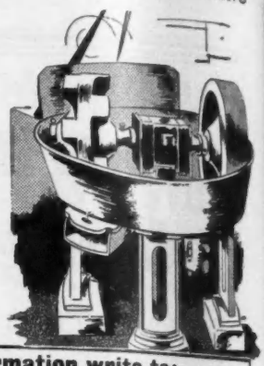

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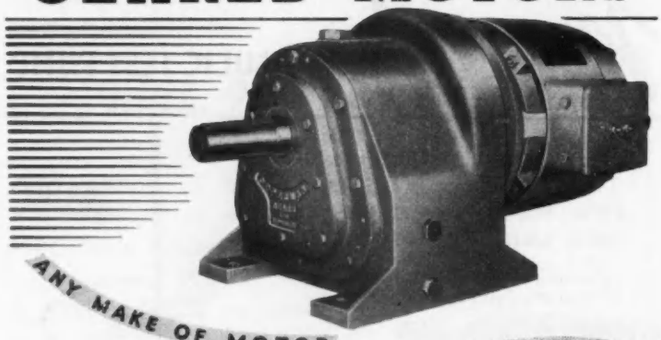

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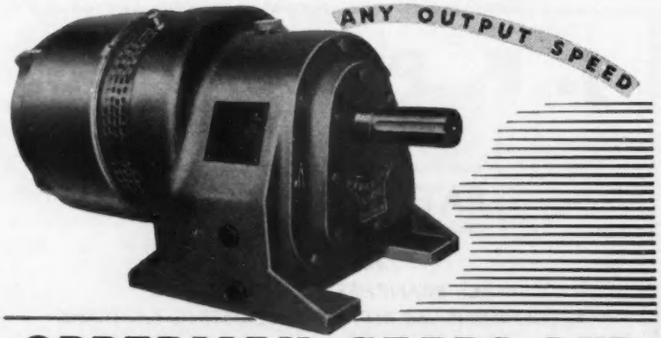

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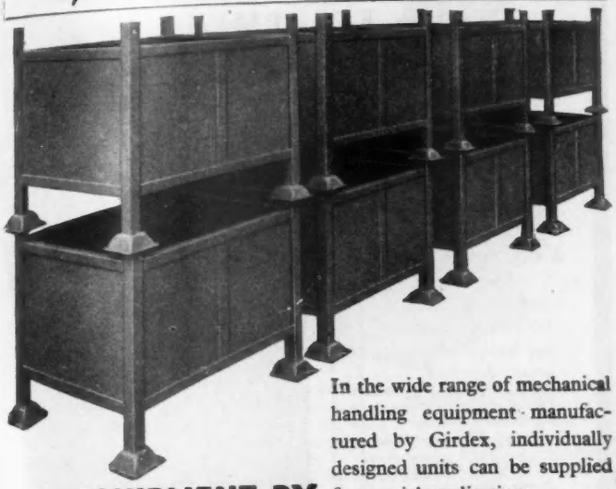

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We are looking for a drive problem that MIRACLO can't tackle. If you think you can beat us, let us know—now. Here is what the MIRACLO belt can do:

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MIRACLO, the plastic belt with the chrome leather driving face, gives amazing results. This is your chance to try it on your worst drive.

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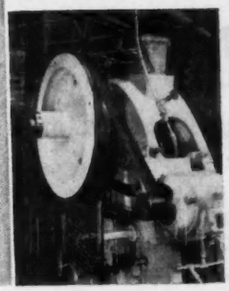

To: **STEPHENS BELTING COMPANY LIMITED**
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☐ We accept your challenge. Please recommend and quote to drive details herewith.
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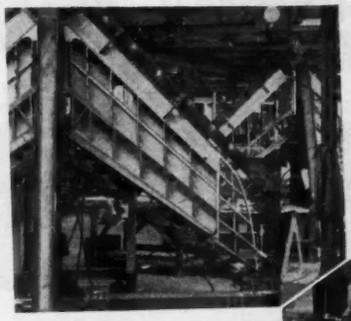

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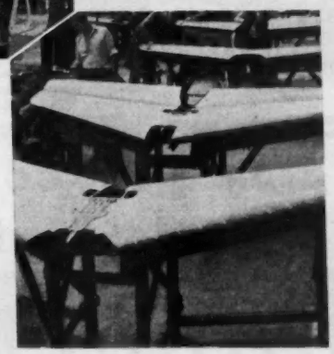

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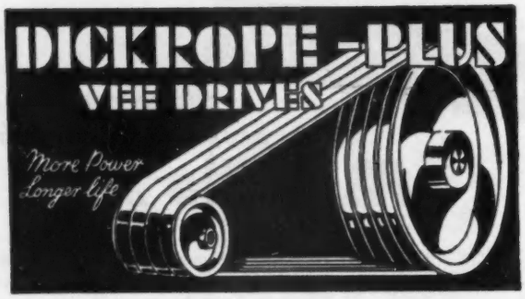

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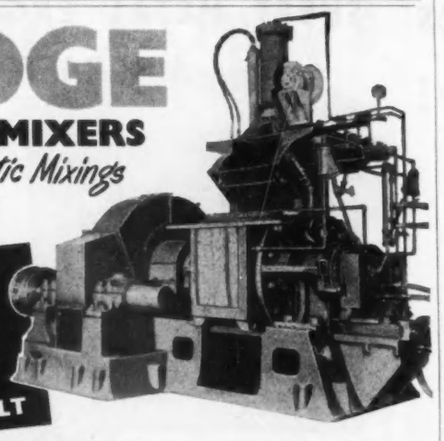

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	cu. in.	c.c.			r.p.m.	ft. in.	mm.	ft. in.	mm.
B	103	1,690	Sp. G. x 2·5	7½	710	5 0	1,524	4 0	1,218
00	263	4,310	Sp. G. x 4	10	485	8 0	2,436	4 0	1,218
1	1,140	18,700	Sp. G. x 24	40	485	13 6	4,114	7 6	2,286
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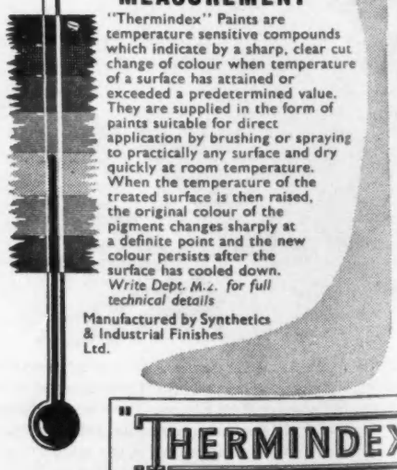

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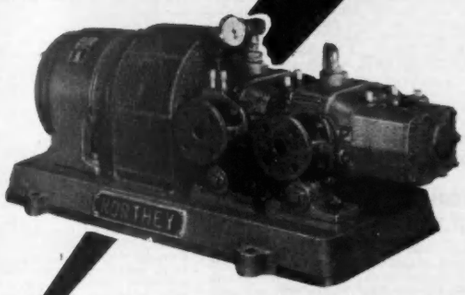
COMPRESSORS & VACUUM PUMPS



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Phone : ALT 2702 (3 lines) Grams : 'VORTEX'

Classified Advertisements continued from Page 5

ASSISTANT CIVIL ENGINEER required for large integrated Iron and Steel Works. The appointment is initially for duties in connection with a two years' plant extension programme, with permanency on demonstration of ability.

Applicants should preferably be between 25 and 35 years of age and have completed their National Service. They should have had at least three years' practical Civil Engineering experience and be competent in the use of surveying instruments.

Applications, giving full details of education, training and experience, should be addressed to: THE CHIEF ENGINEER, APPLEBY-FRODINGHAM STEEL COMPANY, SCUNTHORPE, LINCS. L 435

DESIGNER DRAUGHTSMEN required for interesting development work in alloy steelworks producing a variety of semi-finished products. Machine tool or light mechanical experience preferred. Superannuation scheme, good canteen facilities and modern Drawing Office. Applicants to give age, full details of technical training and experience, and salary required.

Apply LABOUR MANAGER, SAMUEL FOX AND CO., LTD., STOCKSBRIDGE WORKS, NR. SHEFFIELD. L 413

MECHANICAL ENGINEERING DESIGNER-DRAUGHTSMAN required, preferably with experience in Steelworks Hot Mills and Plant design. Modern drawing office, pension scheme and canteen facilities. Replies to state age, technical training and experience with salary required.

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DRAUGHTSMEN (SENIOR AND JUNIOR) required for work in connection with the following branches of Coke Oven and Gasworks plants.

(a) Mechanical and By-Product Plant.
(b) Pipework.
(c) Steelwork for Buildings and Conveyors.

Applicants should be competent men able to work with the minimum of supervision. Technical qualifications to O.N.C. or beyond. Good remuneration and prospects for capable men. Pension scheme. Five-day week; Canteen Facilities.—State age and experience to the PERSONNEL OFFICER (D.O.), WOODALL-DUCKHAM CONSTRUCTION COMPANY LTD., WOODALL-DUCKHAM HOUSE, 63-77, BROMPTON ROAD, LONDON, S.W.3. G 550

BRUSH ELECTRICAL ENGINEERING COMPANY LTD., are expanding their range of Switchgear and require a

SENIOR DEVELOPMENT ENGINEER to work on the development of new prototype designs and research into related fundamental problems. Candidates should be capable of bringing an imaginative and original approach to development problems of both a mechanical and electrical nature. Minimum educational standards are a degree or exemption from A.M.I.Mech.E. or A.M.I.E.E. and previous experience in Switchgear is essential. An attractive commencing salary will be paid and there are excellent opportunities. Service conditions include staff bonus and non-contributory superannuation scheme. Applications, giving full details of experience, etc., to the CHIEF PERSONNEL OFFICER, BRUSH ELECTRICAL ENGINEERING CO., LTD., LOUGHBOROUGH, LEICS. L 453

MECHANICAL ENGINEERING DRAUGHTSMEN
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CIVIL ENGINEERING DRAUGHTSMEN
IMPERIAL CHEMICAL INDUSTRIES LIMITED BILLINGHAM DIVISION

offer attractive salaries in respect of several vacancies for each of the above classes of draughtsmen. Candidates must possess as a minimum qualification, the appropriate Higher National Certificate or its equivalent. Participation in Staff Pension Fund and Profit-Sharing Scheme. Financial assistance towards removal expenses available for married men. Without commitment, write for Application Form to the STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES LIMITED, BILLINGHAM DIVISION, BILLINGHAM, CO. DURHAM, quoting reference U.12. G 633

CIVIL ENGINEERING, STRUCTURAL STEELWORK AND REINFORCED CONCRETE DESIGNER required for major development programme. Applicants must be capable of designing all types of structures and heavy plant foundations. Modern drawing office and canteen facilities. Full details of age, technical training and experience and salary required.

Apply LABOUR MANAGER, SAMUEL FOX AND CO., LTD., STOCKSBRIDGE WORKS, NR. SHEFFIELD. L 412

DRAUGHTSMAN required for Engineering Dept. of Manufacturing concern. Age approx. 24-30. Educated to H.N.C. preferred. Experience in General Engineering, Plant Layout, Buildings, Factory Services, etc. Some electrical experience would be an advantage. Good man capable of working with minimum of supervision would find good conditions of employment, Canteen facilities, pension Scheme etc. Replies giving full details and salary required to MARTIN BLACK & CO. (WIRE ROPES) LTD., SPEEDWELL WORKS, COATBRIDGE. L 127

MANAGER required for Civil Engineering Department in a large industrial undertaking. Applicants must have wide experience and first class technical qualifications.—Apply to BOX L 572, Offices of ENGINEERING.

DESIGN DRAUGHTSMAN required by leading AUSTRALIAN Manufacturer of VALVES. A thorough experience in the design of valves up to 36 in. bore size, for water works, pumping stations and water reticulation, etc., is essential. Assistance with migration cost and housing. Commencing salary, £1300 Aust. Superannuation benefits after two years' service.—Write, stating age, experience and qualifications to THE SECRETARY, HATTERSLEY (ORMSKIRK), LIMITED, ORMSKIRK, LANCASHIRE. L 410

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Design and Construction Engineers of world-wide repute in the petroleum and chemical industries invites applications from junior and senior graduate chemical and/or mechanical engineers

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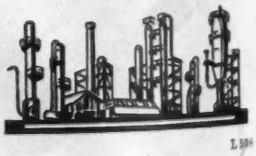
Holiday arrangements will be honoured. Interviews can be arranged to suit applicants by prior appointment by telephoning MUSeum 4010.



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DRAUGHTSMEN to design in aluminium for sales development. Must possess Higher National Certificate in Mechanical Engineering. Location Banbury. Good working conditions and pleasant surroundings. Attractive starting salaries offered up to £800 p.a. with prospects of promotion from drawing board. Pension plan in operation. Send brief details of qualifications and experience to NORTHERN ALUMINIUM CO., LTD., BUSH HOUSE, ALDWYCH, LONDON, W.C.2. G 562

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MECHANICAL ENGINEERS in the Middle East. Applicants aged 25-32 must have served a full five year engineering apprenticeship and possess either National Certificate or Diploma (preferably at Higher level, or A.M.I.Mech.E., or 1st Class M.O.T. Certificate preferably with three years on maintenance work either in mills, mines or factories. Attractive salary plus generous allowance in local currency, free passages out and home, free medical attention, good leave arrangements. Pension Scheme, kit allowance, air-conditioned accommodation.—Write giving full details of qualifications and experience, quoting F.506A, to BOX 1884, c/o 191, GRESHAM HOUSE, E.C.2. L 675

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Minimum qualifications are B.Sc. (Hons.) degree and/or Associate Membership of the Institution of Mechanical Engineers. It would be preferable if applicants had some knowledge of the Rubber or Plastics Industry.

This is a Senior Company appointment and will carry a salary commensurate with ability and achievements. An excellent opportunity for a young practical engineer of energetic and inventive disposition.—BOX L 491, Offices of ENGINEERING.

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WINNINGTON, NORTHWICH,
CHESHIRE.

MECHANICAL ENGINEERING ESTIMATOR.

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Applicants should have experience in these or similar fields.

Pleasant working conditions. Generous salary commensurate with qualifications demanded. Attractive pension scheme. Comprehensive welfare facilities.

Apply to CHIEF PERSONNEL OFFICER, BRYCE BERGER WORKS, STAINES, MIDDX. G 660

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COURTAULDS LIMITED requires a **TECHNICAL ASSISTANT** in the Central Instrument Department in Coventry. Work includes the carrying out of technical calculations, correlation and assessment of data, etc., and assisting in the preparation of instrument control schemes for a wide variety of processes. Experience in the instrument field is not an essential requirement for this position.

Men: Minimum qualification National Certificate in Engineering but Higher National very desirable.

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Candidates should write giving full particulars to the PERSONNEL DEPARTMENT, COURTAULDS LIMITED, 16 ST. MARTINS-LE-GRAND, LONDON E.C.1, quoting reference number B.34. L 467

DO YOU WISH TO CHANGE TO SALES? A large national Company invites applications from **ELECTRICAL ENGINEERS AGED 24 TO 35** years, who have qualified to Higher National Certificate standard and who wish to make a career in Sales as Technical Representatives with opportunities later for promotion to executive status. Previous Sales experience is not essential as those appointed will be given a concentrated course of training designed to give them a thorough knowledge of the product and an insight into the Company organisation. An attractive salary will be paid during training and on appointment to a Sales territory, which may be in any part of the United Kingdom, a car allowance and expenses will be paid. A non-contributory pension scheme is in operation.—Please write, giving full details of career and other relevant information to BOX L 657, Offices of ENGINEERING.

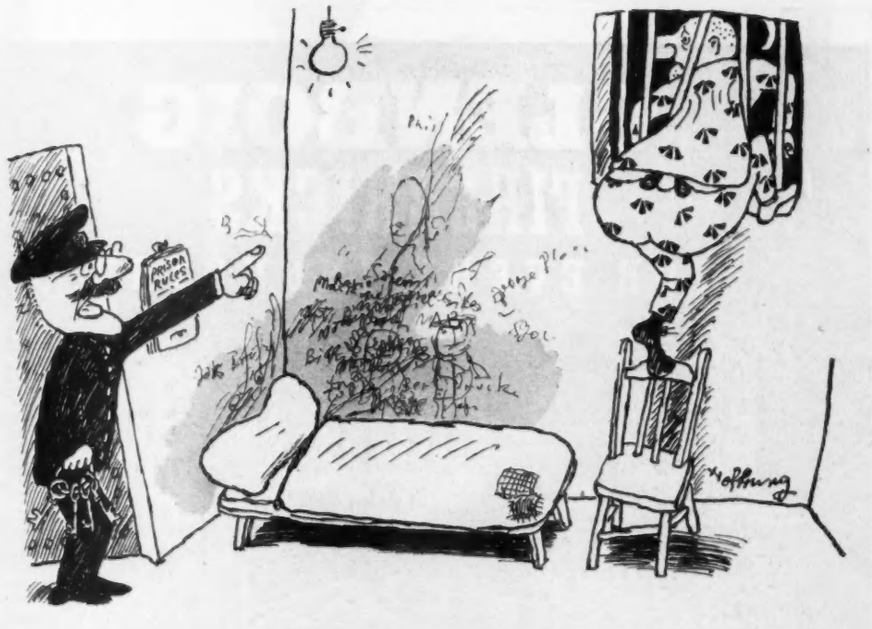
DRAUGHTSMEN. Applications are invited from experienced Mechanical Engineering and Design Draughtsmen to be the nucleus of a newly-formed Central Engineering and Planning Department to deal with expansion projects and new development work for the whole of the Pilkington Group of Companies at home and overseas.

Minimum starting salaries for Draughtsmen of H.N.C. standard range between £715 at age 25, to £840 at age 35, plus agreement and staff bonuses for which they become eligible after one year's service. Conditions include contributory superannuation Fund, assisted house purchase and family education schemes.

Reply, stating age, qualifications and experience, to the GROUP CHIEF ENGINEER, PILKINGTON BROTHERS LIMITED, ST. HELENS, LANCASHIRE. L 659

Forensic Engineers invite application from **ENGINEERING GRADUATES** with good background and industrial experience for responsible and individualistic post. Age preferably 28 to 33 years.—BOX L 610, Offices of ENGINEERING.

Classified Advertisements continued on Page **148**



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LEICESTER. L 577

A Company of Civil Engineering Contractors, specialising in Cement Gun and Pressure Grouting work, have vacancy for
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Applicants should state age, experience and give some idea of salary required to—THE CONCRETE PROOFING COMPANY, LIMITED, 96, VICTORIA STREET, LONDON, S.W.1. L 580

MECHANICAL ENGINEERING DRAUGHTSMAN, preferably holding Higher National Certificate or equivalent, experienced in textile dyeing and finishing machinery. Applications stating age, experience, qualifications, and salary required should be addressed to THE BRADFORD DYERS' ASSOCIATION, LTD., ENGINEERING DEPARTMENT, 39, WELL STREET, BRADFORD, 1. L 611

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Salary commensurate with qualifications but applicant should state present salary.—BOX L 658, Office of ENGINEERING.

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THESE ARE PROGRESSIVE PERMANENT POSITIONS IN AN EXPANDING ORGANISATION. The Company operates a contributory pension scheme and good Canteen facilities exist. Present Holiday arrangements respected. Salary in accordance with age, qualifications and experience. The Works are situated 15 minutes' bus ride from the centre of Ipswich. Applications to Works Manager at the above address. L 602

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preferably with steelworks experience but not essential.
Also opening for
RETIRING OR RETIRED ENGINEERS OR MANAGERS with Coke Oven or Blast Furnace or Steel Plant or Rolling Mill experience. For London office and elsewhere. Full discretion promised.—BOX L 607, Offices of ENGINEERING.

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Draughtsmen, Draughtswomen and Tracers — Mechanical Engineering.

For Engineering Consultants. Positions are permanent, pensionable, with five-day week. Free lunches. Basic Salary above A.E.S.D. minimum rates, plus profit sharing scheme.
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PERSONNEL OFFICER, EWBANK & PARTNERS, LTD., 10/11, GROSVENOR PLACE, LONDON, S.W.1. 200 YARDS HYDE PARK CORNER. SLOANE 0486. G 630

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SENIOR PIPE WORK and **PLANT LAYOUT DRAUGHTSMEN** or **DESIGNERS** preferably with experience on H.P. boilers and turbine plants. London office. Pension Fund; free lunches: 1956 holidays by arrangement. Excellent prospects and salary, for suitable applicants over £800 p.a. to commence. Write BOX EG.224, c/o 191, Gresham House, E.C.2. L 583

CIVIL ENGINEER required, aged 25-30, for Structural Design in London Office. Salary £1000 p.a. Good prospects. Pension Fund. Write stating qualifications and experience to BOX EG.227, c/o 191, Gresham House, E.C.2. L 584

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JOHN BOOTH & SONS (BOLTON), LTD., invite applications for the position of
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A large and progressive Industrial Company invites applications for the appointment of
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JUNIOR MECHANICAL ENGINEER required to train as Technical Representative attached to London Office of Gear Unit Manufacturers. Must have served full apprenticeship in Industrial Workshop and have Drawing Office experience. Age 22 to 26.—BOX L 614, Offices of ENGINEERING.

STRUCTURAL STEEL—DESIGN ASSISTENT required by Westminster consultants. Age range 25/35. Experience in bridgework advantageous. Salary will be considered in relation to experience and qualifications (i.e., H.N.C. studies, A.M.I.C.E., etc.).—BOX L 636, Offices of ENGINEERING.

DRAUGHTSMAN (CIVIL ENGINEERING) required by Consulting Engineers, Westminster. If good progress made with ONC/HNC studies limited practical experience need not be a bar. Remuneration will be in relation to studies and experience.—BOX L 634, Offices of ENGINEERING.

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HEAT TRANSFER AND FLUID FLOW. Research and Development Engineer required by an old-established Engineering Company in the Glasgow area. Applicants, aged 25-30, should have a University Honours Degree in Engineering and some research experience. The work would involve the theoretical design and practical testing of new types of heat exchanger. A good salary would be paid to an applicant with the necessary qualifications. Apply giving age and full particulars to BOX G 583, Offices of ENGINEERING.

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Classified Advertisements continued on Page 150

MECHANICAL ENGINEER required to deal with Tenders and Contracts for the supply of Colliery Winders. Excellent opportunity for man with similar experience.—Apply giving full details of training and experience to PERSONNEL MANAGER, THE GENERAL ELECTRIC CO., LTD., FRASER & CHALMERS ENGINEERING WORKS, ERITH, KENT. L 419

DRAUGHTSMEN required for design and detail work on Mechanical Handling Plant for Gas Works, Power Stations, etc. Experience of this type of work comprising conveyors and associated structures etc. desirable but not essential. Good salaries will be paid to suitable applicants with profit sharing bonus and superannuation schemes. Applications in writing giving full particulars of age, experience and salary required to be forwarded to the CHIEF DRAUGHTSMAN, W. J. JENKINS & CO., LTD., 28, VICTORIA STREET, LONDON, S.W.1. L 95

SENIOR MECHANICAL DESIGNER/DRAUGHTSMEN, age 30 to 40, required for a large British Managed engineering company in Calcutta, manufacturing cranes of all types and capacities, sluice gates and other irrigation equipment, special machine tools, etc. Excellent prospects and terms for those suitably qualified.—Write BOX AP/126, c/o 95, BISHOPSGATE, E.C.2. L 420

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Applications giving full details and quoting reference number 401.E. should be sent to:—

THE MANAGER, STAFF AND TRAINING DEPARTMENT, THE ASSOCIATED ETHYL COMPANY, LIMITED, ELLESMERE PORT, CHESHIRE, to be received not later than 16th June, 1956. L 663

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CIVIL ENGINEERING ASSISTANTS required for Extensive Developments at a modern Iron and Steel Works in the Midlands. Applicants should have experience in design of mass foundations, reinforced concrete and civil engineering work generally. Favourable Housing prospects. Applicants should give details of experience and of salary required.—Apply to BOX L 569, Offices of ENGINEERING.

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CIVIL ENGINEERING DESIGNER/DRAUGHTSMEN are required for Extensive Developments at a large Iron and Steel Works in the Midlands. Applicants should have experience in civil engineering design. Housing prospects are favourable. Applicants should give details of experience and of salary required.—Apply to BOX L 570, Offices of ENGINEERING.

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Applications giving full details should be sent to:—

MANAGER—STAFF & TRAINING DEPARTMENT, THE ASSOCIATED ETHYL COMPANY, LIMITED, ELLESMERE PORT, CHESHIRE, quoting reference number 152.E. L 646

DESIGNER-DRAUGHTSMAN for Hydraulic and heavy mechanical engineering works. Experience in Hydraulics essential. Applicants should preferably be of H.N.C. standard with a sound engineering training.—Apply stating age, qualifications and experience to HENRY BERRY AND CO., LTD., CROYDON WORKS, LEEDS, 10. L 476

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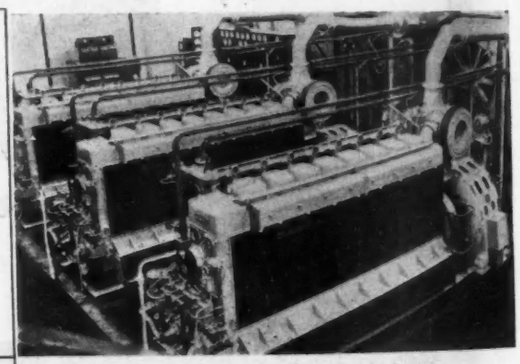

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HEYLIGENSTAEDT PBJ UNIVERSAL FACING AND BORING LATHE, 48 in. dia. chuck, swing approx. 51 in. over bed, variable spindle speeds, feed box, compound toolbox on cross slide, complete.
HASSE WREDE 3-6701 COMBINATION TURRET LATHE, 26½ in. swing over bed covers, 78 in. between spindle and turret, rapid traverses, complete with chuck, turret equipment front and rear toolposts, etc.
SOMUA P.24 S.S. & S.C. LATHE A.G.H. Straight prismatic bed, 32½ in. swing by 33 ft. between centres, two saddles, rapid traverses, complete with 60 h.p. Motor, and full equipment.
All electric equipment wound for 420 Volts three phase 50 cycles. Further particular with photographs from:—
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Classified Advertisements continued on Page 152

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600 C.F.M. BROOMWADE FOUR CYLINDER, cyls. 10 in. dia. by 12 in. stroke, 310 r.p.m. 125 h.p. Slip Ring Motor, C/Parkinson Starter, outer bearing, etc.

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Photographs of the above are available.
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HIGH CLASS LATE TYPE DRILLING MACHINES

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ARCHDALE 6 FT. Medium Duty Centralised control, multi-motor drive, with removable box table. Max. spindle radius 6 ft., max. distance spindle to baseplate 6 ft., M.T. in spindle 5, capacity in C.I. 2¼ in., capacity in M.S. 2 in., 12 spindle speeds 60-1500 r.p.m. h.p. motors 5 and 5. Two available.

ASQUITH 3 FT. 6 IN. LDR Type. Multi-motor drive, max. drilling radius 3 ft. 6 in., max./min. distance spindle to baseplate 4 ft./1 ft. 4 in., 12 spindle speeds 70-2000 r.p.m., M.T. in spindle 4, total h.p. 5.

ASQUITH 3 FT. 9 IN. Portable Universal. Motor drive. Drilling head adjustable in horizontal and vertical planes to any angle, max. drilling radius 3 ft. 9 in., max. distance floor to spindle vertical drilling 5 ft., horizontal drilling 7 ft. 6 in., 6 spindle speeds 41-300 r.p.m.

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ADCOCK & SHIPLEY 28 in. High speed. Motor drive, fixed head, compound table, capacity for holes up to 2 in., M.T. in spindle 4, throat 14 in., max. dia. admitted 28 in., max. distance spindle to table 30 in., 9 spindle speeds 40-750 r.p.m. H.P. motor 6.

For full details on any of the above write to:

SOAG MACHINE TOOLS LIMITED,

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PATENTS.

THE PROPRIETOR OF BRITISH PATENT NO. 680584 for "IMPROVED METHOD AND APPARATUS FOR DRYING SYRUPY MATERIAL," desires to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder. Further particulars may be obtained from MARKS & CLERK, 57 and 58, LINCOLN'S INN FIELDS, LONDON, W.C.2. L 649

THE PROPRIETORS OF PATENT NO. 687620 for "Improvements relating to the Production of Twist Drills" desire to secure commercial exploitation by Licence or otherwise in the United Kingdom. Replies to Haseltine Lake & Co., 28, Southampton Buildings, Chancery Lane, London, W.C.2. L 627

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LATTICE STEEL ERECTION MASTS (light and heavy) 30 ft. to 150 ft. high, for immediate hire.—BELLMAN'S, 21, Hobart House, Grosvenor Place, S.W.1. G 72

MISCELLANEOUS.

FOR THE UNUSUAL IN Technical Gifts—JENCONS (SCIENTIFIC), LTD., MARK ROAD, HEMEL HEMPSTEAD. Boxmoor 4641. L 59

COMPANY MEETING.

ENGINEERING COMPONENTS LTD.

RECORD TURNOVER.

The 21st annual general meeting of Engineering Components, Limited, was held on May 10, in London, Mr. C. C. Griffith, M.C. (the chairman) presiding.

The following is an extract from his circulated statement:

The Group turnover during 1955, was a record for your Companies. Such was our activity that we were able to absorb much of the increased cost of production without increasing our prices, with the final result that a Group Profit of £636,618 was made.

Out of the above profit, taxation—after deducting adjustments for prior years—takes £307,811, and the Subsidiary Companies retain £6,391, leaving your Company a net profit of £322,416. This figure added to the balance of £84,412 brought forward from 1954, gives an available balance of £406,828.

It is proposed to deal with this as follows: Dividend 6 per cent. Cumulative Preference Stock £2,550; Final Dividend of 12½ per cent. less tax on the Ordinary Stock, with the Interim Dividend of 2½ per cent. paid in October, 1955, will absorb £80,360; Transfer to General Revenue Reserve £200,000 and the Balance to carry forward £121,468.

The Consolidated Balance Sheet discloses current assets totalling £2,375,189, against current liabilities of £784,801.

During the year the Issued Capital of the Company was increased by the issue of 750,000 5s. Shares at 8s. each. The necessity for this additional Capital was occasioned by the expansion which is taking place in the Automobile Industry, resulting in our requiring additional space and equipment at our Abergavenny and Reading Works.

EXPORT.—Our Export sales during the year under review were an all-time record, and vigorous steps are being taken to maintain and extend our markets.

After reviewing the activities of the Associated Companies in Australia and South Africa, the statement continued: We have developed during the year several new gasketing materials, and are continually experimenting in an endeavour to find still more satisfactory jointing materials of improved sealing properties. Our research also continues at Abergavenny into the problems associated with the filtration of air and liquids.

Our close tie with the Automobile Industry makes us largely dependent on their fortunes, but it must be realised that our customers are still doing a big spares business and this is reflected in the Company's turnover, and therefore we are as much concerned with the number of Motor Vehicles in use as in the number of new vehicles manufactured. However, I would not like to prophesy what the future holds in store; I can only say that up to the present our sales for the current year have been satisfactory.

The report was adopted. L 630

SOAG

REBUILT & GUARANTEED

HORIZONTAL BORERS

KEARNS "S" Type, with collet type spindle, motor drive, with separate motor for table feeds, table size 22in. by 16in. long. Table traverse 24in., cross table traverse 12in., vert. adjustment of spindle slide 12in., six spindle speeds 80-1,000 r.p.m.

KEARNS No. 1 Standard Type, motor drive, facing head only, max. facing cap. 20in., sliding table 33in. by 24in., revolving top table 24in., by 24in., max. distance facing head to outer stay 4ft., 24 speeds 4-300 r.p.m.

SCHARMANN HBSF3, motor drive, facing head, power feeds and rapid power motion to table and spindle, screwcutting and verniers, dia. of spindle 4in., travel of spindle 31½in., facing cap. 39½in., boring capacity 19½in., working surface of table 47½in. by 554in., max. distance spindle nose to outer stay 102½in., 24 spindle speeds 4·7-960 r.p.m., h.p. of motor 10.

RICHARDS PRT2, motor drive, continuous feed facing head, power feeds and rapid power traverse in all directions, spindle dia. 3in., facing capacity 30in., max. traverse of spindle 48in., main table 48in. by 30in., revolving top table 36in. by 36in., 32 spindle speeds 3·5-300 r.p.m.

CINCINNATI GILBERT, motor drive, power feeds and rapid power traverse in all directions, spindle dia. 3½ in., traverse of spindle 30in., table working surface 60in. by 48in., 24 spindle speeds 19-1,070 r.p.m.

PEARN RICHARDS No. 4 Standard Type, motor drive, facing head only, max. facing capacity 48in., sliding table 60in. by 36in., revolving top table 36in. by 36in., max. distance facing head to outer stay 7ft. 7in., 32 speeds 1·5-160 r.p.m. (as illustrated).

KEARNS No. 2 Patent Type, motor drive, with traversing spindle and continuous automatic facing head, main table with detachable quartering table, vernier scales, outer boring stay, spindle dia. 3in., facing capacity 30in., main table 48in. by 30in., auxiliary top table 36in. by 36in., 24 spindle speeds 3·1-250 r.p.m., h.p. of motor 5.

NILES WV9 Floor Type Horizontal Borer, flanged motor drive, spindle dia. 3½in., facing head dia. 24½in., travel of spindle 31½in., travel of column 4ft. 4in., max./min. distance baseplate to spindle 60in./18in., 16 speeds 3-350 r.p.m.

Write for full detail on any of the above to:-

SOAG MACHINE TOOLS LTD., JUXON ST., LONDON, S.E.11.

Phone: RELiance 3373
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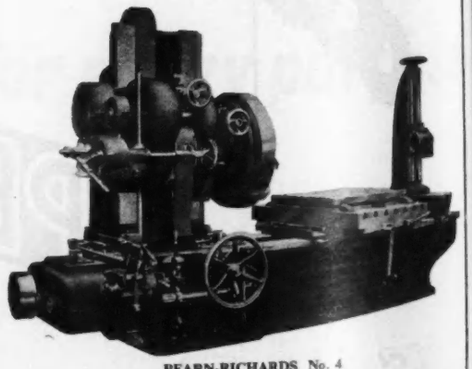

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Created for the joint design and construction of nuclear power plant in the Commonwealth and other countries, it is private industry's first international agreement in this field—and the logical outcome of Mitchell's wide experience over the past 35 years in all branches of engineering and electrical supply.

MITCHELL COMPANIES—active in the atomic sphere since 1950—are at present engaged on three important contracts for the United Kingdom Atomic Energy Authority.

AT CHAPELCROSS *Amman, Dumfriesshire, where work is beginning on Britain's biggest atomic power station, the* **Mitchell Construction Company** *are the main civil engineering contractors.*

AT CAPENHURST *near Chester, where work at the Authority's diffusion plant is in progress, the same Company is building six cooling towers. Here, also,* **Mitchell Engineering Limited** *has been awarded a substantial contract for piping and plant installation.*

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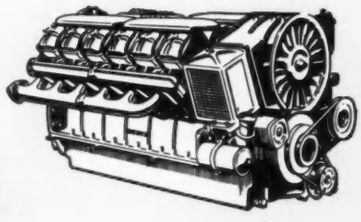
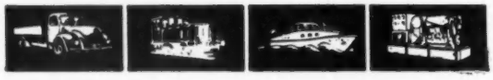
began in 1948 to build air-cooled diesel engines in large series. 7 years after, in 1955, the oldest engine manufacturers in the world had built and sold 150.000 air-cooled DEUTZ diesel engines totalling 7.5 Million B.H.P. These equipment engines are used all over the world for every kind of application. DEUTZ builds air-cooled 1 to 12-cylinder diesel engines with an output range from 5 to 250 B.H.P. for road vehicles, rail vehicles, water craft, working machines in all fields of application, generator sets for stationary and mobile electric and power plants.





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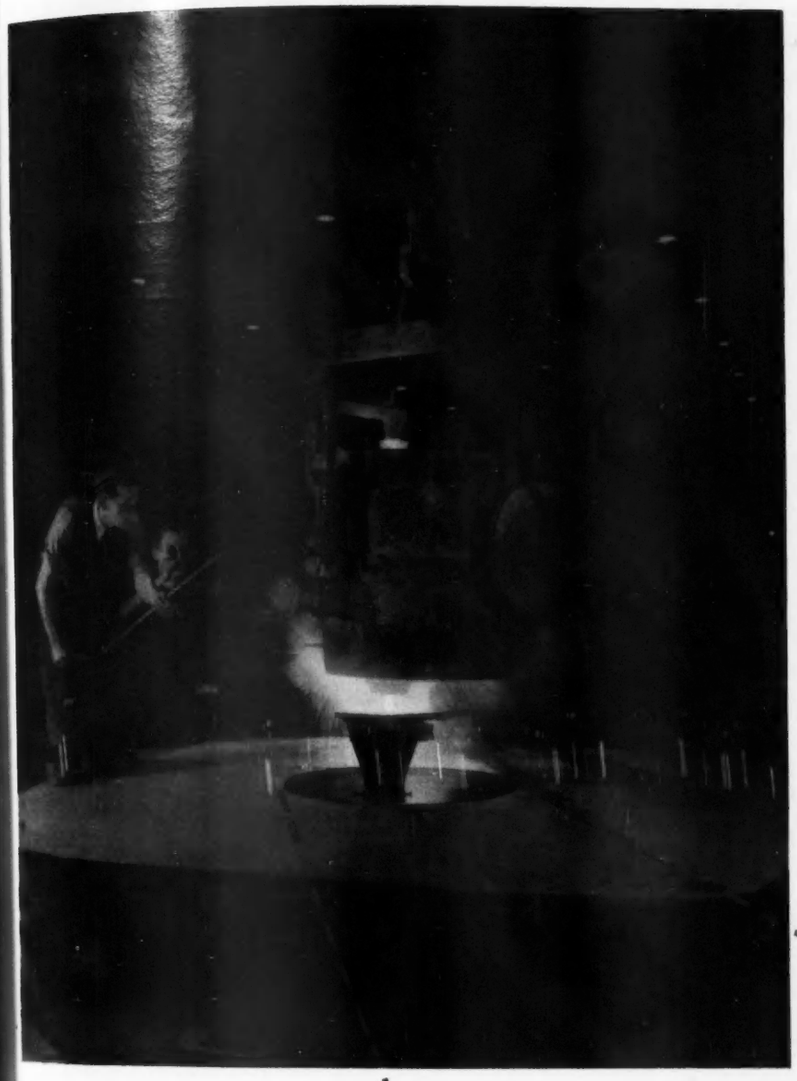

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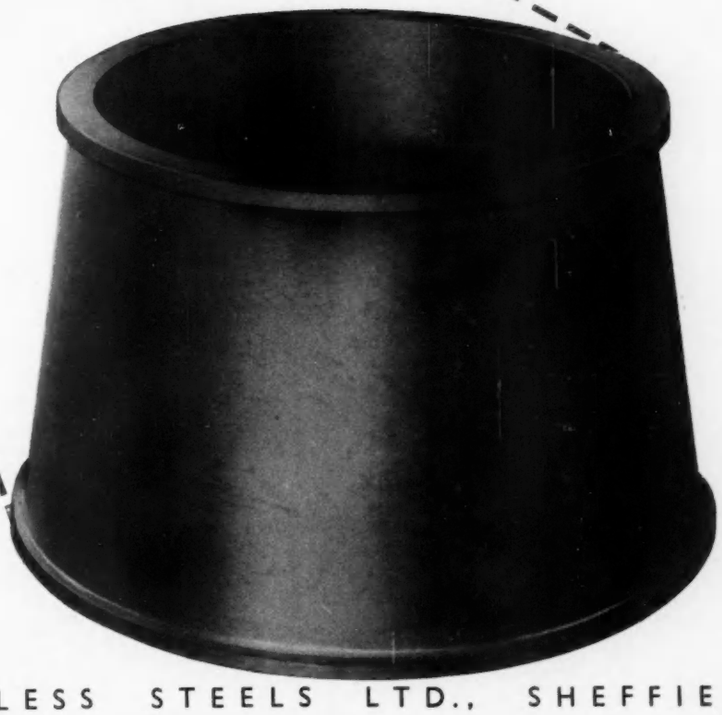

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ENGINEERING

An Illustrated Weekly Journal

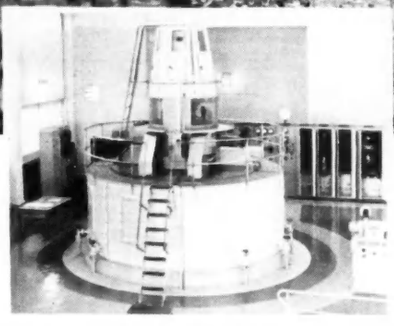
HYDRO-ELECTRIC EQUIPMENT

Power for New Zealand by

New Zealand mutton and wool from the district of Otago, in South Island, is mainly exported through Dunedin. 48,500 kVA of electric power is provided for this flourishing city by harnessing the Waipori river at four points in its course from Lake Mahinerangi. This river has provided electric power since the beginning of the century, but the Dunedin City Council have developed it into a major project to match increasing prosperity. BTH equipment plays a large part in this scheme, harnessing the power of natural resources.

B T-H

A general view of No. 4 dam.



One of the BTH 9,000-kVA, 6.6-kV alternators.

The present No. 1 station, begun in 1928, was the first fully-automatic hydro-electric power station to be equipped by BTH. No. 2 station was equipped with four BTH alternators between 1928 and 1939. Stations 3 and 4, with BTH 9,000-kVA, 6.6-kV alternators, were officially inaugurated in March 1955. All stations have BTH switchgear and automatic control equipment.

BRITISH THOMSON-HOUSTON

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